AN ATLAS

OF

ASTRONOMY

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A SERIES OF SEVENTY-TWO PLATES,

WITH INTRODUCTION AND INDEX.

BY

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PREFACE.

I HAVE been frequently asked by readers of my little book, "Starland," to recommend a set of maps which would facilitate their study of the Heavens. It happened that while I was answering some of these queries, I received an invitation from the enterprising publishers of the present work to prepare a new Astronomical Atlas. This seemed an opportunity for attempting to introduce some features that I could not find in any one of the existing Atlases, excellent though many of them doubtless are. In the first instance, I only thought of preparing a work which should meet the wants of beginners in Astronomy. However, the scheme gradually developed, and at length it appeared that, while the wants of my young friends were suitably supplied, it was possible to give the Atlas a scope that would make it more widely serviceable than if it were intended merely as a handbook to accompany so elementary a book as "Starland." The result is the present work, comprising seventy-two Plates, with the necessary explanatory matter.

In the introduction will be found sufficient information about the several Plates, and the methods of using them. It is, however, desirable in this place to draw attention to certain characteristics of the work, and to make my acknowledgments to the friends who have kindly assisted me.

The four charts for Sun Spot observations, Plates 19 and 22 inclusive, are based on drawings due to Professor Arthur W. Thomson, whose assistance I was glad to obtain. We introduced, however, some modifications, and the charts as actually presented have been drawn by Dr. Rambaut. I have to thank Mr. H. H. Turner, Chief Assistant of Greenwich Observatory, for the kindness with which he has supplied the Table of Heliographic Longitude of the Centre of the Sun's Disc (see p. 20). I would refer in this connection to the admirable annual known as the *Companion to the Observatory*.

My thanks must next be offered to Mr. Thomas Gwyn Elger, for complying with my request that he would prepare the set of Moon Charts forming Plates 23 to 38 inclusive. The series contains careful charts of the lunar formations; it also gives a picture of the Moon for nearly every age at which it can be satisfactorily observed, up to the time of the full. Each of these pictures is furnished with a key and index of names, and it is believed that students of our satellite will find these plates of much service in identifying the various lunar objects.

Another feature of the present work consists of what I have designated the "Index to Planets." The identification of these bodies is often a matter of difficulty to a beginner; his Maps will enable him to name the Stars, but the shifting positions of the Planets are apt to give trouble. I have removed this difficulty for the next decade, at all events, by providing a simple method of learning in a few seconds the approximate position of every important planet. The "Index to Planets" will enable the reader to discover what Planet it is at which he is looking, to find out the time to seek for any Planet he wants to observe, or to ascertain the place where it is to be found. The Table of Planetary Phenomena, up to A.D. 1902, was computed by Mr. J. Hind Bell.

Perhaps I ought to say a few words as to a certain omission from this Atlas, though the size to which it has already swollen seems to render any apology for its not being larger unnecessary. It contains no plates showing the spectra of the heavenly bodies. An entire Atlas, which must be no small one either, would be necessary to do any justice to this great branch of astronomical work; accordingly, I came to the conclusion that it had better be altogether omitted.

The drawings of the planet Jupiter, on Plate 10, have been copied from Dr. O. Lohse's observations, in the third volume of the publications of the *Astrophysikalische Observatorium*, at Potsdam. I am indebted to Professor H. C. Vogel for his kindness in placing this beautiful work at my disposal. The ideal tail of a comet, represented on the same Plate, is a sketch by Professor Bredichin. I owe the use of this figure to Dr. R. Copeland and Dr. J. L. E. Dreyer.

For the pictures of Saturn, forming Plate 11, I am indebted to the courtesy of the late Mr. R. A. Proctor's executors, and his publishers—Messrs. Longmans & Co. These views form the frontispiece to Proctor's well-known treatise on "Saturn and its system."

The Map of the Pleiades, on Plate 12, showing the remarkable nebula associated with that group of stars, is due to the Messrs. Henry. For the catalogue of the positions of the stars in this cluster (see pp. 11-12) I have depended on Dr. Elkin's elaborate researches.

Plate 14, representing the great Nebula in Andromeda, and the great Nebula in Orion, have been derived from Dr. Isaac Roberts' remarkable photographs of these bodies.

Plate 9 contains a chart of Mars, drawn by Dr. Rambaut. I have to acknowledge the kindness with which Mr. Green and Mr. Knobel permitted me to make use of their beautiful drawings of the planet.

Plate 15, representing Donati's Comet, and Plate 16, representing Coggia's Comet, have been taken from that repertory of exquisite astronomical representation, *The Annals of the Harvard College Observatory.* For this and many other kindnesses my acknowledgments are due to Professor Pickering.

To the Harvard College Observatory I am also indebted for the view of the solar prominences on Plate 17. The photograph of the Corona, on the same plate, was contributed by Mr. A. A. Common. The view of the sun spot, also on the same plate, I copied from *Knowledge*, by permission of the editor, Mr. A. Cowper Ranyard, whose kindness on this, as on other occasions, I am here glad to acknowledge.

The selection of subjects for the plates, and the method in which they should be treated, has received much consideration for more than four years. Summarizing the work, it may be said that Mr. Elger has specially drawn sixteen of the plates, that Dr. Rambaut has specially drawn forty-nine, and that the remainder, to the number of seven, have been obtained from other sources. I ought, however, to add that Plate 18, though drawn by Dr. Rambaut, was suggested by a somewhat similar picture in Secchi's *Le Soleil.*

Not only two-thirds of the plates, but also a considerable part of the letterpress forming the introduction, are due to Dr. Rambaut, whose cordial co-operation has been of the utmost value to me in all parts of the work.

In the revision of the entire volume, I have once again to acknowledge the valuable aid of my esteemed friend, Rev. M. H. Close.

R. S. B.

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INTRODUCTION.

CHAPTER I.—THE GENERAL MAPS.

Plate 1.

THE CIRCLES OF THE SPHERE, REFRACTION, AND PARALLAX.

Fig. 1.—The observer is supposed to be placed at the centre O of this figure, and the sphere which surrounds him is the Sphere of the Heavens. The nomenclature of the different parts is given in the margin of the plate, and the meaning of other technical terms used here or elsewhere will be found in the Index.

The *Right Ascension* of a celestial object is the arc, usually expressed in time, measured on the Equator from the point X, at the intersection of the Ecliptic and the Equator, to where the Meridian through the object cuts the Equator. The *Declination* of the object is the arc on this Meridian between the object and the Equator.

Fig. 2.—The refraction of light in the atmosphere raises the apparent place of a celestial object towards the zenith. The line marked "true direction" shows the curved path of a ray of light as it traverses the air. When the ray enters the eye, the direction that it has at the last part of its journey is marked as the "apparent direction." The dotted lines show an extreme case in which a ray of light proceeding from below the horizon is so refracted as to raise the apparent position of the body above the horizon. Instances of this occur both at sunrise and sunset, for the Sun, when *appearing* to be touching the horizon, lies entirely below it. The actual amount of refraction has been necessarily exaggerated in the diagram. The angle through which a body is apparently thrown upwards towards the zenith increases with the zenith distance.

The following Table gives the amount of the refraction at different zenith distances from 0° to 90°, when the height of the barometer is 30 inches and the temperature 50° :—

Table of Refractions.

Apparent Zenith Distance.	Refraction.	Apparent Zenith Distance.	Refraction.	Apparent Zenith Distance.	Refraction.
0°	0″·0	35°	′ 40″·8	70°	2′ 38″·8
5	5·1	40	48·9	75	3 34 3
10	10·3	45	58·2	80	5 19·8
15	15·6	50	1 9·3	85	9 54·8
20	21·2	55	1 23·4	87	14 28·1
25	27·2	60	1 40·6	89	24 21·2
30	33·6	65	2 4·3	90	33 46·3

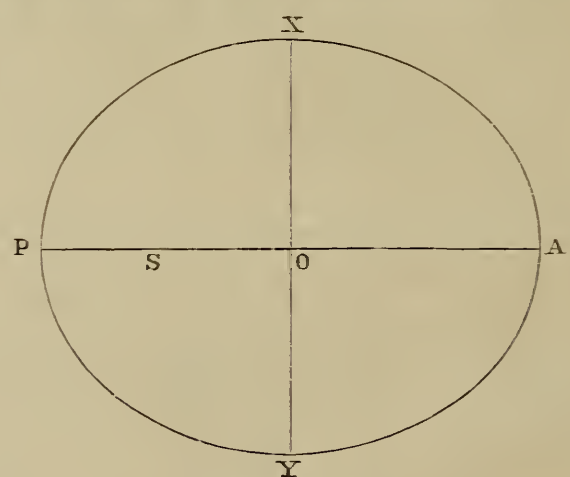
FIG. 3.—Diurnal Parallax is the angle between the direction of a celestial object as seen from the Earth's surface, and the direction of the object if it could be seen from the centre of the Earth. To the remarks that will be found on the plate, it is necessary to add that the apparent place of a star as seen from the Earth is, strictly speaking, different from that in which it would be seen by an observer at the Sun. The angle subtended by the radius of the Earth's orbit at the Star is known as the Annual Parallax. It is generally too small a quantity to be measurable.

PLATE 2.

THE INNER PLANETS.

In the attempt to represent the orbits of celestial bodies on maps or charts, it must always be remembered that, except in the case of orbits which happen to lie in the same plane, it is impossible to depict on any drawing the veritable position of more than one. We are obliged to resort to some process of a more or less artificial character. For instance, we take the plane of the Ecliptic, that is, the Earth's orbit, as the plane of the paper, and then we simply draw on it the orbits of the other bodies, notwithstanding that their planes are inclined to the Ecliptic. The points in which the real orbit passes through the plane of representation are called the *Nodes*, the ascending node being that at which the planet passes from the southerly to the northerly side of the plane. Each orbit may be conceived to be turned around its line of nodes till its plane coincides with the Ecliptic. It is thus that Plate 2 is produced.

The path which every planet describes is an *ellipse*, and the Sun is situated in one of the *foci*. The line P A through the two foci is the *axis major* of the ellipse. It is bisected in O at the *centre* of the orbit. The line X Y through O, perpendicular to A P, is the *axis minor*. The semi-axis major O P is the *mean distance* of the planet from the Sun. The *eccentricity* of the ellipse is the ratio of O S to O P. The point P, nearest the Sun, is the *Perihelion* of the orbit. The point A, remotest from the Sun, is the *Aphelion* of the orbit. The points A and P are known as the *Apses*. The time that the planet takes to go round its orbit is the *Periodic Time*. The smaller the ratio of O S to O P, the less is the eccentricity of the orbit, and the more does the ellipse resemble a circle. The orbits of the more important planets have small eccentricity.



THE ELLIPSE.

The following extract from the Nautical Almanac will be useful in connection with the present plate, as well as in other parts of this Atlas.

Explanation of Astronomical Symbols and Abbreviations.

☉ The Sun.	♂ Mars.	☌ Conjunction.
☾ The Moon.	♃ Jupiter.	□ Quadrature.
☿ Mercury.	♄ Saturn.	☍ Opposition.
♀ Venus.	♅ Uranus.	☊ Ascending Node.
⊕ or ♁ The Earth.	♆ Neptune.	☋ Descending Node.
h Hours.	° Degrees.	N. North. S. South.
m Minutes of Time.	′ Minutes of Arc.	
s Seconds of Time.	″ Seconds of Arc.	E. East. W. West.

0.	♈	Aries	0°	IV.	♌	Leo.	120°	VIII.	♐	Sagittarius	240°
I.	♉	Taurus	30	V.	♍	Virgo.	150	IX.	♑	Capricornus	270
II.	♊	Gemini	60	VI.	♎	Libra	180	X.	♒	Aquarius	300
III.	♋	Cancer	90	VII.	♏	Scorpio	210	XI.	♓	Pisces	330

The orbits of the planets Mercury, Venus, Earth, and Mars are represented in this plate, and for illustrating the use of it we take the orbit of Mercury. The point A is the Aphelion where the planet is most distant from the Sun. The next point marked is the Ascending Node ☊, where the orbit comes through the plane of the paper, the inclination being 7° 0′, as given in the table in the upper right hand corner of the map. P is the Perihelion, where Mercury is nearest the Sun. For a complete revolution this planet requires a period of 87·969 days. Similar remarks apply to the other orbits. Thus, for instance, Mars, the outermost of the four planets shown in this figure, revolves in the period of 686·951 days. Its Perihelion is marked P, and Aphelion A, the Ascending Node is ☊, and the inclination is 1° 51′. The inclinations of the cometary orbits are given in the right hand lower corner of the plate. The orbits of the three following comets are drawn, Biela's Comet, Comet I. 1866, and Comet III. 1862. These have been chosen because they possess the additional interest of being the paths of the three chief meteor swarms. The famous showers of "Leonids," which appear from November 12th to 14th, at intervals of about 33 years, move in the track of Comet I. 1866. The "Andromedes," or meteors of November 27th, have the same orbit as Biela's Comet, and the "Perseids" pursue the course of Comet III. 1862. In the case of each of the cometary orbits the Descending Node has been marked on the plate, as it is at this Node that the Earth meets the associated meteor swarm.

Plate 3.

THE OUTER PLANETS.

The innermost orbit on this plate is that of Mars, for those belonging to planets still closer to the Sun would be too small to be shown in a figure of the scale necessary for the outer planets. Next to Mars comes the zone of minor planets, the innermost represented being Medusa, with a period of 3·12 years, and the outermost, Hilda, with a period of 7·90 years. Beyond these lie the orbits of Jupiter, Saturn, Uranus, and Neptune. The positions of the several Perihelions and Aphelions are marked, as are also the Ascending Nodes.

The orbit of Encke's Comet is interesting as being the smallest of cometary orbits, as well as on other grounds. Plate 3 contains also a more complete representation of the orbit of Biela's Comet than was possible on Plate 2, where a part of the same ellipse was shown. Halley's Comet revolves in a larger elliptic orbit, with a period of about 76 years, while a portion of the remarkable parabolic orbit of the great Comet of 1882 is also indicated.

Plate 4.

THE PLANETARY SYSTEM.

Plate 4 is intended to show the comparative sizes of the different planets. The opportunity has, however, been taken to add some further information with regard to these members of the solar system. The largest planet is Jupiter, with an equatorial diameter of 87,500 miles. Its departure from the circular outline is indicated on the plate, and the oblateness of the planet is thus shown. The polar diameter of Jupiter is 82,500 miles. The period of rotation is taken to be 9h. 55m. The inclination of the equator of Jupiter to the Ecliptic is 3° 5′. The equatorial diameter of Saturn is 74,000 miles, and his polar diameter is 68,000. The period of rotation of the planet is 10h. 14m. 0s., and the inclination of his equator to the Ecliptic is 28° 10′. A plan of the ring system surrounding Saturn is also shown, and the dimensions of the several concentric circles are set down. Thus the radius of Saturn is 37,000 miles, and the radius of the outer margin of the outer ring is 85,000 miles.

The facts as regards the other planets are as follows :—

Names.	Mean Diameters in miles.	Axial Rotation.	Inclination of Equator to Ecliptic.
Neptune	34,500 ...	Unknown ...	35° ?′
Uranus	31,700 ...	Unknown ...	101 ?
Earth	7,918 ...	$23^{h.}$ $56^{m.}$ $4^{s.}$ ...	23 28
Venus	7,660 ...	See below ...	?
Mars	4,200 ...	24 37 33 ...	28 42
Mercury	2,992 ...	See below ...	?

The periods of rotation for Venus and Mercury are probably identical with their periods of revolution, viz., 224·701 days and 87·969 days respectively.

Plate 5.

THE SEASONS AND THE TIDES.

The figure in the right-hand upper corner shows the apparent diurnal path of the Sun at different seasons of the year. The latitude at which the observer is stationed is supposed to be that of the centre of the British Isles. On the shortest day, 21st December, the apparent motion of the Sun is in the Tropic of Capricorn, of which only a small part is above the horizon. On the 21st June, the longest day, the Sun moves in the Tropic of Cancer, of which only a small part is below the horizon.

The central figure shows the Earth, in different positions in its orbit, as it would be viewed from an elevation of 20° above the Ecliptic. It must of course be understood that in these figures the size of the Earth is enormously exaggerated in proportion to the size of its orbit. This figure is intended to explain the significance of the circles by which the Earth is divided into zones. On the 21st June all the region inside the *Arctic Circle* has no night, while the entire region within the *Antarctic Circle*, lying entirely within the shaded hemisphere, has no day. By the ensuing 21st December the conditions are interchanged. The *terrestrial tropics* are the two circles of north and south latitude on the Earth, over which the Sun is vertical on the 21st June and 21st December respectively. The *vernal equinox* is on the 21st March, and the *autumnal equinox* on the 23rd September. On both these dates day and night

are equal all over the Earth. The various circles on our globe are further illustrated by the figure in the lower corner right-hand side, in which the Earth in its orbit is supposed to be viewed from the pole of the Ecliptic, that is, as it would be seen by an observer in that point of the heavens indicated by a perpendicular to the plane of the Earth's orbit drawn through the Sun.

The *apparent annual* path of the Sun in the heavens is shown in the top figure, left-hand side. It is specially intended to explain the significance of the Equinoxes. On the 21st March the Sun ascends from the south of the Equator to the north, and on the 23rd September it descends from the north of the Equator to the south.

Tides are the disturbances in the level of the ocean arising from the attraction of the Moon and the Sun. The figure at the lower part of the plate illustrates the remarkable fact that there are protuberant masses of water at opposite sides of the globe. Though these are caused by the tide-producing body, they are not necessarily, nor indeed generally, in line with it. The Moon is a much more efficient tide-producing agent than the Sun. The figure at the top of the plate is to explain the expressions *spring* and *neap* tides. At the time of New Moon, and at Full Moon, the tides raised by the Sun and Moon conspire, and an exceptionally high tide is produced, which is called a *spring tide.* At the First or Last Quarter Moon, the Sun tends to produce low water when and where the Moon tends to produce high water, and consequently, the result is a small or *neap tide.*

Plate 6.

SYSTEMS OF SATELLITES.

This plate exhibits the relative dimensions of the orbits of the systems of satellites attending certain of the planets. With the exception of the system surrounding Mars, which is on a scale twenty times as large as the rest, the orbits are all laid down on a uniform scale of half a million miles to the inch. The periods of revolution of the satellites around their primaries are also marked on the orbits approximately. More complete numerical information than it has been found convenient to represent on the map is given in the following tables.

The Moon.

Mean distance from the Earth is 238,000 miles. The time of revolution around the Earth is 27 days 7 hrs. 43 mins. 11 secs.

The Satellites of Mars.

Name.	Mean Distance from Centre of Mars.	Periodic Time. hrs.	mins.	secs.
Phobos	5,800 miles	7	39	14
Deimos	14,500 „	30	17	54

The Satellites of Jupiter.

Name.	Mean Distance from Centre of Jupiter.	Periodic Time. Days	hrs.	mins.	secs.
I.	262,000 miles	1	18	27	34
II.	417,000 „	3	13	13	42
III.	664,000 „	7	3	42	33
IV.	1,170,000 „	16	16	32	11

The Satellites of Saturn.

Name.	Mean Distance from Centre of Saturn.	Periodic Time. Days	hrs.	mins.	secs.
Mimas	118,000 miles ...	0	22	37	27·9
Enceladus	152,000 „ ...	1	8	53	6·7
Tethys	188,000 „ ...	1	21	18	25·7
Dione	241,000 „ ...	2	17	41	8·9
Rhea	337,000 „ ...	4	12	25	10·8
Titan	781,000 „ ...	15	22	41	25-2
Hyperion	946,000 „ ...	21	7	7	40·8
Iapetus	2,280,000 „ ...	79	7	54	40·4

The Satellites of Uranus.

Name.	Mean Distance from Centre of Uranus.	Periodic Time. Days	hrs.	mins.
Ariel	119,000 miles	2	12	29
Umbriel	166,000 „	4	3	27
Titania	272,000 „	8	16	56
Oberon	363,000 „	13	11	7

The Satellite of Neptune.

	Mean Distance from Centre of Neptune.	Periodic Time. Days	hrs.	mins.
Anonymous	220,000 miles	5	21	3

Plate 7.

PHASES OF THE MOON, AND SOLAR AND LUNAR ECLIPSES.

Relative positions of Sun, Earth, and Moon. The hemisphere of the Moon that is directed towards the Sun is of course brilliantly lighted, and the *corresponding phases* of the Moon are caused by the varying proportions in which the illuminated hemisphere is directed towards the Earth.

When the Moon comes between the Earth and the Sun, a *Total Eclipse of the Sun* takes place on those regions of the Earth which the Moon's shadow covers. At those places where the Moon's disc does not altogether conceal that of the Sun a Partial Eclipse of the Sun is seen. The case of *minimum totality* arises when the vertex of the conical shadow of the Moon just reaches the Earth. If the shadow of the Moon does not reach the Earth, then an *Annular Eclipse of the Sun* takes place.

An *Eclipse of the Moon* arises from the entry of the Moon into the shadow of the Earth. In the majority of revolutions the Moon passes quite clear of the *Earth's Shadow*, and there is *no Eclipse;* when the Moon is entirely immersed in the Earth's shadow, there is a *Total Eclipse;* and when it is partially immersed there is a *Partial Eclipse.* These three cases are illustrated at the foot of the plate.

Plate 8.

PHASES OF THE PLANETS.

This plate exhibits the appearances of the planets Mars, Venus, and Saturn when occupying different parts of their orbits. A reference to Plate 2 makes it clear that the distance between the Earth and Mars must vary considerably at different dates, according to the positions

which the bodies occupy in their paths around the Sun. Of course, if the orbits were both circular, it is clear that the greatest possible separation between the two bodies would be attained at every *conjunction*, that is to say, whenever the Earth, Sun, and Planet are in a straight line (at least in their projected orbits), the Earth and Planet being at opposite sides of the Sun. The same diagram makes it plain that the least distance apart would occur at every *opposition*, that is, whenever the three bodies, as represented in their projected orbits, were in a straight line, with the Earth in the middle.

The eccentricity of the orbit of Mars considerably modifies the circumstances. It will be seen by referring to Plate 2, that an opposition occurring in the latter half of the year will generally be more favourable (*i.e.*, bring the two bodies closer together) than one in the first half of the year, and that the most favourable opposition happens when the Earth and Planet are situated in about 333° longitude. On the other hand, an opposition occurring in longitude 153° will be as unfavourable as possible. The Earth's longitude on August 26th is 333°, and on February 22nd it is 153°; hence the most favourable opposition of Mars will occur on August 26th, and the closer to that date the opposition happens the better. The most unsuitable oppositions are about February 22nd.

The greatest distance at which the two planets can possibly be separated is attained when the Earth's longitude is 333°, and that of Mars 153°; that is to say, when *conjunction* occurs about August 26th.

Figures 1, 4, and 5 in the upper part of the left-hand portion of Plate 8, show the relative apparent sizes of the planet—at most favourable opposition (August 26th), at least favourable opposition (February 22nd), and at its greatest possible distance. These views illustrate the advantage of an opposition occurring somewhere near the end of August, when the appearance of the planet is to be studied.

When the lines from the Sun to the Earth and the Sun to the Planet are at right angles, the Planet is said to be in *quadrature*. A very distinct phase is then perceptible in Mars, by which about a quarter of its diameter is cut off. The appearances of the planet at western and eastern quadrature, as shown in an inverting telescope, and the apparent size of the planet on the same scale as the other figures, is also given. For the topography of the planet the reader may refer to Plate 9. As to the times and seasons for observing Mars in its varying aspects, reference may be made to the Index to Planets, *see* page 35.

Since the orbit of Venus lies inside that of the Earth, the appearances of this planet differ considerably from those of an exterior planet like Mars. It is obvious that the nearest approach of the two bodies will occur at *inferior conjunction*, or when Venus and the Earth are on the same side of the Sun; and that the greatest distance between them will occur at *superior conjunction*, or when the two bodies are at opposite sides of the Sun. It might at first sight, therefore, be supposed that at inferior conjunction the planet would be seen best, being then apparently largest; and that it would be least favourably placed at superior conjunction. The relative apparent sizes of this planet *just before* inferior, and at superior, conjunction are shown in the lower part of the left-hand portion of this plate; but since in the former configuration the illuminated part of the globe is reduced to a very thin crescent, and since in both cases the planet is enveloped in the Sun's rays, in neither of these phases is it suitably situated for observation.

Venus attains its greatest brightness as an evening star about a month after its greatest elongation east. The greatest brightness of the same planet as a morning star precedes by about a month its greatest elongation west.

The second figure has been drawn to represent the size and shape of Venus when most brilliant. The third figure exhibits the appearance of Venus when situated at a distance of 40°

from the Sun in the further part of its orbit. In this position it presents a *gibbous* form. It will be seen, however, that the diminution of light caused by its increased distance from the Earth, more than compensates for the larger proportion of the illuminated surface visible, so that, on the whole, the amount of light received from the planet is less than when it is in the position corresponding to Figure 2. In the Index to Planets, p. 34, the method of finding the position of Venus for any date within the next decade is explained.

For the general details of the planet Saturn reference may be made to Plate 11. In this place we discuss only the varying appearances of the rings. The right-hand portion of Plate 8 contains twelve figures depicting the different aspects which the ringed planet presents according to the position it happens to occupy in its orbit. In connection with the Table of Planetary Phenomena, p. 33, this plate will enable the reader to determine with considerable accuracy the appearance of the rings at any time. If the opposition of Saturn occurs in the middle of January in any year, it will be found that Fig. 1 represents the system. The rings are then opened nearly to their full extent, and the upper portion of the ball just extends beyond the outer margin of the rings. If the opposition occurs in February, the rings will be found to have closed up somewhat, and to appear as shown in Fig. 2. If the opposition occurs in March, the rings will shrink almost to a straight line, as in Fig. 3. At oppositions occurring in April, May, and June, the appearances will be as in Figs. 4, 5, and 6, the rings appearing the more open the more nearly the date of opposition approaches June. Figs. 7—12, in a similar way, show the changes which this system will undergo at oppositions occurring in the latter six months of the year.

It must of course be understood that the appearance here depicted for any month will not recur every year in that month, but will only be seen in those years in which the opposition of the planet occurs during the month in question, and then only with accuracy at the date of opposition. But as Saturn takes a period of no less than 29½ years to accomplish its revolution, the alteration in its appearance will vary very little for several months before and after opposition, so that the figure for any month may be taken to represent the appearance of the system during the year in which opposition occurs in that month. Thus, in the year 1892 the Table of Planetary Phenomena tells us that the opposition of Saturn takes place in March, whence we learn that during this year the rings will be almost edgewise towards us. Again, in the year 1899 opposition occurs in June, from which we infer that during that year the rings will be open to their fullest extent, and most favourably situated for observations.

These pictures have, as usual, been drawn to represent the planet as seen in an astronomical telescope, which always inverts the object, so that Figs. 3—8 exhibit the appearance of the system when the northern face of the ring is tilted towards us so as to become visible, while in Figs. 1 and 2, and 9—12, it is the southern side of the rings which is seen.

To facilitate reference a column has been added to the Table of Planetary Phenomena, p. 33, to show which of the phases are presented in the corresponding opposition. For example, if the opposition is in October, the column alluded to gives the number 10, which means that during the year in question the planet Saturn will present, when visible at all, a phase resembling that shown in Fig. 10 on Plate 8.

Plate 9.

CHART OF MARS.

This map represents the surface of Mars on the stereographic projection. It has been compiled (with only two exceptions, where, as shown by Mr. Knobel in 1884, the balance of evidence appears to incline otherwise) from Mr. N. E. Green's Chart of Mars, published in the

Transactions of the Royal Astronomical Society, Vol. XLIV. The details of this chart have been compared with views of the planet by Schiaparelli, Trouvelot, Terby, De la Rue, Lockyer, Knobel, Christie, Maunder, Brett, Dreyer, and others, and no form is introduced that has not been confirmed by the drawings of at least three observers, so that any markings to be found there may be taken to represent a real feature of the planet. The exceptions to which I have referred are called by Mr. Green—Phillips Island and Leverrier Land. The first of these appears to be connected by a tongue of land between Burton Bay and Dawes Forked Bay with Beer Continent. I have consequently changed the name to Phillips *Land;* and Herschel II. Strait, which by the same alteration ceases to be a strait, I have called Herschel II. *Inlet.* Leverrier Land I have omitted altogether, as Mr. Knobel was unable to find any trace of it under very favourable circumstances in 1884. The Lassell Sea, too, of Mr. Green appears to be only a prolongation of Nasmyth Inlet, and the name has been accordingly omitted.

The smaller maps at the top and bottom of the plate are also on the stereographic projection, and represent the polar regions of the planet, showing the form and extent of the northern and southern snow-caps as seen by Mr. Green in 1877.

In comparing this plate with the appearance of the planet in the telescope, it should be remembered that parts near the centre of the maps are by this method of projection represented on a smaller scale than those near the edge. For the times to observe Mars, reference may be made to the Index to Planets, p. 35.

Plate 10.

JUPITER AND COMETS.

Owing to the absence of permanent features on Jupiter, the utmost that maps can do is to represent the planet in some of its ever-changing aspects. I have chosen that epoch which is specially interesting in connection with the remarkable red spot on Jupiter. This is shown on Figs. 4, 5, 7, 8, 9, 12, in the Southern (uppermost) Hemisphere of the Planet. The red spot was conspicuously visible for three years, the remarkable circumstance being that while it completed a rotation around the planet in 9 hours 55 minutes 36 seconds, there was a white spot in the vicinity which completed its journey in 5 or 6 minutes less.

As to the seasons at which Jupiter may be observed with advantage, reference may be made to the Index to Planets, p. 36. It is there shown how the position of the planet for any month during the years 1892-1902 can be readily ascertained. For the System of Satellites surrounding Jupiter, reference may be made to Plate 6.

The Tail of a Comet directed from the Sun. This picture is to show the relation of the tail of the comet to the orbit in which the body is revolving around the Sun. The direction of the tail is, speaking generally, governed by the law that it points from the Sun.

Bredichin's Theory of Comets' Tails. Three types are presented in the tails of Comets, as demonstrated by Bredichin. The direction of motion of the Comet is shown by the arrow-head on the line through the nucleus. The straightest of the three tails is most probably formed of Hydrogen. The tail of the second type is of a more complex character, and seems to be due to the presence of Hydro-Carbons in varying proportions in the body of the Comet. The short tails of the third type are due to Iron, or to Chlorine, or to some other similar element with a high atomic weight. It will of course be understood that this does not purport to represent the view of any actual Comet. Most Comets possess tails either of one of the types here shown, or sometimes a composite tail of two types.

Plate 11.

SATURN.

For the study of this plate reference may be made to Plates 4, 6, 8, for various details, while the Index to Planets, p. 37, can be consulted for the purpose of showing when Saturn can be observed in the phases depicted. The lower of the three views exhibits the planet as shown on March 23rd, 1856. In that year the opposition took place in December, and accordingly the phase of the planet exhibited is that represented in the 12th month, that is, in Fig. 12 on Plate 8.

The uppermost figure shows one of those highly-interesting occasions when the ring, being turned edgewise, becomes almost invisible. It represents the opposition of March, 1862, so that throughout the year the rings presented nearly the aspect of Phase No. 3 in Plate 11.

Plate 12.

THE PLEIADES.

This plate is a reproduction of a chart of the Pleiades, prepared from photographs taken by MM. Paul and Prosper Henry at the Paris Observatory. The photographs were exposed for four hours, so that stars as faint as the 17th magnitude made their impression. The picture shows the vast nebulosity which occupies the spaces between the principal stars of the cluster.

The most remarkable features of this nebula are—the spiral jet projecting from the north preceding side of Maia, the somewhat similar but longer projection from Electra towards Alcyone, the barred or streaked structure of the nebula in the neighbourhood of Merope, and, above all, the long narrow streak running to the north of Alcyone, through Nos. 10 and 24, enveloping five other smaller stars in its course, and offering conclusive evidence of the physical connexion of the nebula with the stars forming the cluster.

The relative positions of the brighter stars of this group have been measured with great accuracy by Bessel and Dr. Elkin with the heliometer, by M. Wolf with the filar micrometer, and by Professor Pritchard with the duplex micrometer. A comparison of the results of Bessel with those of Dr. Elkin, made forty-five years later, show that the relative proper motions of these stars, if any, is exceedingly small. This apparent fixity of the stars with regard to each other is often put to a practical use in the Observatory. The distance separating the various members of the group, as determined by these observations, may be looked upon as standard distances, by measuring which the equivalent in angular measure of a revolution of a micrometer screw or other measuring apparatus may be ascertained. As some of my readers may have occasion to employ the stars for this purpose, I append a list of sixty-nine stars, with their places as determined by Dr. Elkin for 1886·0 (the epoch of the Chart). In the first column is contained Elkin's number; in the second, the corresponding number in Bessel; in the third, the magnitude as determined by Argelander in 1853; and in the fourth and fifth columns, the R.A. and Declination of the star. The numbers given in the Key Map are those of Bessel.

It must, however, be borne in mind that, before using these figures for comparison with micrometer measures, it will be necessary to apply the corrections for Precession, Aberration, Nutation, and Refraction; the methods of doing which will be found in a treatise on practical astronomy, such as Brünnow's "Spherical Astronomy."

Positions of 69 Stars in the Pleiades for 1886·0.

Elkin's No.	Bessel's No.	Mag.	R.A. 1886·0. °	′	″	Declination, 1886·0. °	′	″
1	...	8·3	54	14	8·71	+ 24	0	45·20
2	...	8·0		18	16·37	24	11	44·14
3	...	9·1		24	20·96	23	46	19·73
4	...	8·7		24	42·93	24	2	3·70
5	16 g Celaeno	6·5		30	23·92	23	55	47·80
6	17 b Electra	4·7		31	35·58	23	45	14·46
7	...	8·9		34	58·92	23	54	16·85
8	...	8·6		35	2·29	23	20	37·74
9	18 m	6·3		35	24·05	24	28	49·82
10	19 e Taygeta	5·0		36	20·06	24	6	30·99
11	...	8·9		38	6·75	24	33	48·97
12	...	9·2		38	57·37	24	31	40·25
13	Anon. 1	8·2		40	1·10	23	40	37·51
14	Anon. 2	8·8		41	48·52	24	6	19·91
15	Anon. 3	9·0		42	17·88	23	43	31·89
16	...	9·2		43	25·88	24	32	55·13
17	Anon. 4	8·1		42	43·59	23	58	40·51
18	Anon. 5	9·1		43	7·37	24	16	10·76
19	Anon. 6	9·0		43	39·36	23	55	52·09
20	20 c Maia	4·8		45	38·91	24	0	37·85
21	Anon. 7	8·2		46	22·39	23	40	54·18
22	21 k Asterope	7·0		46	44·49	24	11	50·93
23	22 l Asterope	7·0		48	51·74	24	10	16·13
24	Anon. 8	8·0		51	47·40	23	50	21·06
25	Anon. 9	8·1		52	21·07	23	50	1·08
26	23 d Merope	4·5		53	23·97	23	35	32·34
27	Anon. 10	8·0		55	6·84	23	53	57·05
28	...	8·4		57	15·11	23	16	7·00
29	Anon. 11	9·1		58	13·42	23	44	52·75
30	Anon. 12	7·5	55	2	56·99	24	9	56·13
31	...	8·4		3	47·09	24	27	55·62
32	Anon. 13	8·5		4	29·60	23	38	27·46
33	...	9·2		5	46·04	23	55	21·00
34	Anon. 14	9·0		6	7·26	23	25	36·38
35	Anon. 15	8·5		7	29·19	23	46	27·81
36	Anon. 17	7·9		8	0·44	23	22	20·50
37	Anon. 18	8·0		8	10·56	23	47	6·96
38	24 p	8·0		8	36·66	23	45	46·97
39	Anon. 19	7·5		8	47·95	23	26	58·77
40	Anon. 20	8·0		9	2·83	24	14	5·42
41	Anon. 21	8·6		9	39·76	24	18	13·44
42	Anon. 22	7·0		9	35·09	23	33	39·82
43	Anon. 23	8·0		10	20·20	23	19	29·49
44	Anon. 24	7·0		10	35·77	23	56	5·89
45	25 η Alcyone	3·0		10	37·29	23	45	6·17
46	Anon. 25	8·2		12	49·93	23	15	23·17
47	Anon. 26	9·0		14	17·05	23	11	25·05
48	...	7·0		19	28·50	24	38	8·98
49	Anon. 27	8·5		21	34·13	23	58	0·05
50	...	9·2		20	5·54	23	47	24·18
51	Anon. 28	7·0		23	58·18	23	4	11·76

POSITIONS OF STARS—*continued.*

Elkin's No.	Bessel's No.	Mag.	R.A. 1886·0.			Declination, 1886·0.		
			°	′	″	°	′	″
52	Anon. 29	7·8	55	25	40·64	23	59	39·54
53	...	9·0		26	57·35	23	49	48·81
54	26 s	7·0		32	37·74	23	30	27·00
55	27 f Atlas	4·0		35	45·22	23	42	13·90
56	28 h Pleione	6·2		36	3·72	23	47	14·31
57	Anon. 30	8·4		36	28·30	23	32	14·47
58	Anon. 31	8·0		37	16·71	24	2	48·57
59	Anon. 32	7·5		38	31·69	24	1	54·61
60	Anon. 33	7·8		39	40·10	23	53	55·51
61	...	9·2		41	18·08	23	16	47·58
62	Anon. 34	7·2		44	24·39	23	21	49·16
63	Anon. 35	9·2		44	41·66	23	53	46·26
64	Anon. 36	8·5		46	52·49	23	52	9·15
65	Anon. 37	7·9		47	14·34	24	0	4·27
66	Anon. 38	7·5		47	55·89	23	30	3·67
67	...	9·0		51	49·24	24	19	7·00
68	Anon. 39	7·7		54	58·72	24	8	53·32
69	Anon. 40	7·3	56	1	24·73	23	36	57·15

PLATE 13.

ORBIT OF A BINARY STAR.

The determination of the orbit of a Binary Star is a problem of so much interest that I have thought it desirable to include it in this Atlas, as the process is one of a comparatively simple character.

The observations which are employed for the purpose consist of measurements of the distance r between the two component stars, expressed in seconds of arc, and also of the position angle θ; that is to say, of the angle formed by the line joining the two stars of the pair, with the line from the chief of the two stars to the pole. When a sufficient number of these data have been accumulated by a long series of observations, then the following process, chiefly due to Sir John Herschel, will enable the orbit of the Binary to be ascertained. To illustrate the method, let us take the case of the star λ Cygni, which is situated in R.A. 20 h. 43 m., Decl. + 36°·1, the components being 5·0 and 6·3 respectively in magnitude.

The figures in the following table are taken from Prof. Glasenapp's paper, "Orbites des Etoiles Doubles du Catalogue de Poulkova," in which he investigates the orbit of this interesting pair.

The first column contains a current number, the second the date of the observation, the third the observed position angle θ, the fourth contains the observed distance r. It should be remarked that when observations at widely different dates are brought together, the correction for precession must be attended to.

No.	Date.	θ	r	No.	Date.	θ	r
		°	″			°	″
1	1842·66	118·4	0·55	20	1868·66	90·6	0·70
2	43·63	122·1	·62	21	69·68	92·6	·62
3	44·91	120·3	·67	22	70·67	89·6	·63
4	45·73	115·7	·63	23	71·69	90·2	·76
5	47·76	110·2	·62	24	72·61	87·6	·53
6	49·84	109·5	·62	25	73·72	89·3	·60
7	50·92	107·7	—	26	74·73	80·5	·67
8	51·90	108·3	·59	27	75·69	88·3	·69
9	52·68	107·4	·61	28	76·82	82·5	·68
10	53·85	100·7	·66	29	77·65	84·7	·48
11	54·71	102·8	·61	30	78·64	84·6	·61
12	56·83	101·5	·70	31	79·68	82·4	·72
13	57·67	97·3	·63	32	80·58	83·8	·83
14	58·59	91·5	·69	33	81·73	80·2	—
15	59·70	97·0	·61	34	82·85	77·0	·67
16	60·81	96·5	·72	35	83·73	80·1	·56
17	61·63	92·7	·65	36	86·78	75·5	·77
18	65·73	93·9	·45	37	87·83	71·8	·63
19	66·92	91·9	·60	38	88·83	70·6	—

The first step in the process consists in laying down on a sheet of paper ruled into small squares (that generally used being known as *papier millimètrique*) a point for each observed position; the angle θ, in degrees and decimals of a degree, being taken as an abscissa along the horizontal lines, and the date (t.), in years and decimals of a year, as an ordinate along the vertical lines.

In Plate 13 this has been done, but on a very much smaller scale than will be found convenient in practice, so as to keep all the points thus obtained within the limits of the page.

We have then to draw among these points, by the mere judgment of the eye, and with a free but careful hand, a curve presenting as few and slight departures from them as possible, consistently "with a large and graceful sinuosity, which must be maintained at all hazards." It is this part of the process in which judgment and experience on the part of the computer is of most advantage, and no care should be spared in obtaining as good a curve as possible, since all the subsequent results will depend upon the skill with which it has been drawn.

From the drawing we find the angles (α) which the tangents to this curve, at points corresponding to every fifth degree of position angle, make with the horizontal lines. This angle may be obtained with considerable accuracy by setting a protractor so that its diameter is a tangent to the curve at the required point, and reading off the two points at which any one of the horizontal lines intersects its circumference. The mean of these two readings will give the angle α.

We know by a property of elliptic motion that r is proportional to $\sqrt{\tan \alpha}$. In order to construct the apparent ellipse, we multiply this by some convenient factor. In the example before us we have taken $r = 60^{\text{mm.}} \times \sqrt{\tan \alpha}$. We thus obtain the following quantities :—

θ	a	tan a	$\sqrt{\tan a}$	r
°	°			mm.
75	43·3	0·9424	0·971	58·3
80	46·7	1·0612	1·030	61·8
85	50·1	1·1960	1·094	65·6
90	51·1	1·2393	1·113	66·8
95	50·8	1·2261	1·107	66·4
100	46·5	1·0538	1·027	61·6
105	41·6	0·8878	0·942	56·5
110	33·7	0·6669	0·817	49·0
115	26·4	0·4964	0·705	42·3
120	20·5	0·3739	0·611	36·7

With these values of r and θ, the points numbered from 1 to 10 in Fig. 2 are plotted down, S being the position of the principal component, and the line SN being taken as the zero of position angles. If the observations had been free from error, and the curve in Fig. 1 were perfect, these points would all necessarily lie on an ellipse. As, however, the observations are more or less affected by error, we have to be satisfied with drawing amongst these points the ellipse which appears to suit them all best. This, in Fig. 2, is represented by the ellipse AEHFBK, and is the *apparent orbit* of the Satellite.

The next step is to determine the real orbit, and with this object we first find the centre of the apparent ellipse. To obtain it, draw *any* pair of parallel chords; the line joining their middle points is a diameter, the middle point of which (C) is accordingly the required centre of the ellipse.

The point C is the projection of the centre of the real orbit, and S is the focus of the latter. Hence, A is the projection of the periastron or apse of the real ellipse near the principal star, and the ratio $\frac{CS}{CA}$, which is unaltered by projection, is the eccentricity (e). In this case we find $e = 0{\cdot}53$.

Take SD $= \frac{CA^2 - CS^2}{CA}$. Draw any chord EF parallel to BA. Bisect it at G. Join CG, and through S draw HK parallel to CG. Then will HK be bisected at S. Draw DO at right angles to SK, and make DL and DM each equal to SK. Join SL and SM. Then S☊, the internal bisector of the angle LSM, is the line of nodes (or the line in which the plane of the real orbit intersects that of the apparent orbit), and the longitude of the node (Ω) is the angle NS☊ Thus we find $\Omega = 104^\circ{\cdot}5$. The inclination ($\gamma$) of the true orbit to the apparent is given by the equation, $\cos\gamma = \frac{SM - SL}{SM + SL}$. In the case before us we find $\cos\gamma = 0{\cdot}4761$, and consequently $\gamma = 61^\circ{\cdot}6$. If the semi-axis-major is denoted by a, we have $a = \frac{SL + SM}{2(1 - e^2)}$, and since SL + SM $= 73{\cdot}5^{\text{mm.}}$, we find $a = 51{\cdot}03^{\text{mm.}}$ on the arbitrary scale we are using.

The angle NSA $= \varpi =$ the longitude of periastron. This we find to be $256^\circ{\cdot}8$.

The angle between the line of nodes and the major axis of the real ellipse, which is usually denoted by λ, is found from the formula,

$$\tan\lambda = \sec\gamma\tan(\varpi - \Omega),$$

from which we obtain in the case of this star $\lambda = 132^\circ{\cdot}2$.

We have next to find P, the period; n, the mean motion; and ϵ, the date of periastron passage. These are obtained by means of the following formulæ, in which v and u denote respectively the true and eccentric anomalies in the real orbit:—

$$\left.\begin{aligned} n(t-\epsilon) &= u - e\sin u \\ \tan\frac{u}{2} &= \sqrt{\frac{1-e}{1+e}}\tan\frac{v}{2} \\ \tan(v+\lambda) &= \sec\gamma\tan(\theta-\Omega) \end{aligned}\right\}\ldots\ldots\text{A.}$$

Taking t_1 and t_2 to represent the dates 1842·66 and 1888·83 respectively—being those of the first and last observation—we have from the curve in Fig. 1 the corresponding values of θ, viz.: 123°·9, and 72°·3. Substituting these values in the third of equations A, we find $v_1 = 264°·3$, and $v_2 = 174°·9$. Hence by means of the second equation we have $u_1 = 297°·0$, and $u_2 = 170°·8$, and substituting these values in the first we obtain

$$n\,(1842{\cdot}66 - \epsilon) = 324°{\cdot}1$$

$$n\,(1888{\cdot}83 - \epsilon) = 166{\cdot}0.$$

From these two equations we find

$$\epsilon = 1937{\cdot}27.$$
$$\text{and } n = -\ 3°{\cdot}426 \text{ per annum.}$$

Also, since $P = \dfrac{360°}{n}$ we obtain P = 105·1 years.

It now only remains to determine the length of the semi-axis-major in seconds of arc. We have already found this to be 51·03mm. on our arbitrary scale, by calculations founded on the observed position angles. For the purpose of finding its length in seconds of arc, we must have recourse to the observed distances which, in consequence of the large errors to which they are liable, have been discarded in the previous steps.

The position angle corresponding to each date of observation is read off from the interpolating curve, and the distance in the apparent orbit at the corresponding position is measured. We thus obtain, expressed in our arbitrary scale, the series of distances corresponding to the actually observed distances. Dividing the sum of the observed distances (22″·38) by the sum of the corresponding computed distances ($2072^{\text{mm.}}{\cdot}22$), we obtain the value, in seconds, of one millimetre, on the scale we have been employing, which is thus found to be

$$1^{\text{mm.}} = 0''{\cdot}0108.$$

Multiplying this by 51·03, which is the value of a in millimetres, we find $a = 0''{\cdot}55$.

We thus have all the elements of the orbit, viz.:—

$$e = \frac{\text{CS}}{\text{CA}} = 0{\cdot}53.$$

$$\Omega = \text{NS}\,\Omega = 104°{\cdot}5.$$

$$\gamma = \text{Cos}^{-1}\frac{\text{SM}-\text{SL}}{\text{SM}+\text{SL}} = 61°{\cdot}6.$$

$$\varpi = \text{NSA} = 256°{\cdot}8.$$

$$\lambda = \text{Tan}^{-1}\left[\sec\gamma\tan(\varpi-\Omega)\right] = 132°{\cdot}2.$$

$$n = \frac{u_2 - u_1 - e\,(\sin u_2 - \sin u_1)}{t_2 - t_1} = -\ 3°{\cdot}426 \text{ per annum.}$$

$$\epsilon = \frac{t_1+t_2}{2} - \frac{u_1+u_2-e\,(\sin u_1+\sin u_2)}{2\,n} = 1937{\cdot}27.$$

$$P = \frac{360°}{n} = 105{\cdot}1 \text{ years.}$$

$$\text{and } a = 0''{\cdot}55.$$

Plate 14.

NEBULÆ.

These have been reproduced from the beautiful photographs obtained by Dr. Isaac Roberts at Maghull, near Liverpool. The picture on the right is of the great nebula in Andromeda, 31 M., R.A. 0 h. 37 m., Decl. 40° 40′, obtained with an exposure of 240 minutes with a silvered glass reflector of 20 inches aperture, on December 28th, 1889.

The figure on the left represents the great nebula in Orion, R.A. 5 h. 30 m., Decl. S. 5° 28′. See *Mon. Notices, R.A.S.*, vol. xlix., p. 296. This photograph was taken at Maghull on the 4th February, 1889, with an exposure of 205 minutes.

In examining photographs of nebulæ, it should always be borne in mind that when the exposure is sufficiently long to bring out the faint details of the diffused gaseous material, it is necessarily too long for the brighter stars. They are accordingly over exposed, and represented as blots instead of the small discs that are shown on stellar photographs when suitable exposure has been given. The rays from the star at the top of the Orion photograph are due to an instrumental cause, and do not belong to the star itself.

Plate 15.

THE COMET OF DONATI, 1858.

This plate represents the Comet of Donati in 1858, which was one of the most conspicuous of this class of objects that has been seen in modern times. The drawing from which it has been taken was made by Mr. G. P. Bond, on October 5th, 1858, at the Harvard College Observatory.

Donati's comet illustrates Bredichin's doctrine on the tails of these bodies, as represented in Plate 10. It seems as if Donati's comet had been furnished with an elaborate hydrocarbon tail of type 2, and also with a hydrogen tail. The latter was in the form of a cone, and the edges of the cone are seen on the plate in the form of the two streamers.

Plate 16.

THE COMET OF COGGIA, 1874.

The drawings of the Comet of Coggia, which appeared in 1874, were made by Mr. Trouvelot, at the Harvard College Observatory. The view on the left shows the aspect on 10th June, and the other picture that on July 9th. These views exhibit a structure which such bodies occasionally possess.

CHAPTER II.—THE SOLAR MAPS.

Plate 17.

SOLAR PHENOMENA.

The picture on the right is taken from a photograph by Dr. Janssen. It shows a remarkable sunspot, and exhibits the texture of the solar surface in the vicinity. *See* "*Knowledge*," February 1st, 1890.

The picture on the left, taken from a photograph obtained at the Lick Observatory, represents the Solar Corona during the Total Solar Eclipse of January 1st, 1889. *See* "*The Observatory*," March, 1889.

The picture below this exhibits typical forms of the prominences which project from the Sun's limb. A portion only of the Sun's disc is shown in the figure.

The Monthly Maps, 39—50, can be used to indicate the locality of the Sun for each month. It lies always within the zone marked "Track of the Planets." The following list gives the number of the plate in which, in the corresponding month, the Sun lies at the position defined by the intersection of the central meridian (*i.e.*, the line joining the south point to the north point on the Map) with the "Track of the Planets."

Position of Sun.

January ...	45	April	48	July	39	October ...	42
February ...	46	May	49	August ...	40	November	43
March ...	47	June	50	September...	41	December...	44

Example.—In what part of the heavens is the Sun situated in August?

Solution.—The table just given refers to Plate 40. The central meridian cuts the track of the planets in Leo, in the neighbourhood of which the Sun will accordingly be found at the time named.

Plate 18.

PATHS OF SPOTS ACROSS THE SUN'S DISC.

The Sun rotates around its axis, in the same direction as the Earth, in a period of 25·38 days. In consequence of this movement the spots make their first appearance on the eastern limb of the disc, unless the point at which they occur happens to be turned towards the Earth at the time of the eruption.

Spots then traverse the disc parallel to the Sun's equator, are carried round the invisible side, and reappear, at the eastern limb, after a period of 25·38 days. Sometimes, of course, a spot may close up before the point of the surface at which it occurred is again turned towards the earth; and, on the other hand, they frequently perform one, two, or more, complete revolutions.

The axis, around which the Sun rotates, is inclined to the Ecliptic at an angle of 82° 45′. The inclination of the Sun's equatorial plane to the Ecliptic is therefore 7° 15′.

The ascending node of the Sun's equator is the point at which a spot on the equator of the Sun would be carried by the Sun's rotation from the southern to the northern side of the Ecliptic, and the longitude of the node is the angle which the direction of this point makes with the direction of the *First Point of Aries* as seen from the Sun's centre. The actual value of the longitude of the ascending node is 74°. Its position is marked on Plate 2.

Plate 18 shows the paths along which the spots appear to travel at different dates. They are here represented as actually on the face of the Sun, and not as seen through the inverting telescope that the astronomer ordinarily uses.

On December 6th, the Earth is in the line of nodes, and consequently in the plane of the Sun's equator, and the paths pursued by the spots will therefore appear projected into straight lines. Again, on June 5th, when the Earth is in the opposite point of its orbit, it will be again in the plane of the Sun's equator, and the paths of the spots will again appear projected into straight lines.

On March 4th, the Earth, being then 90° from the node, will be depressed below the Sun's equator by an angle of 7° 15′, and the paths of the spots will appear as ellipses of considerable curvature, with their convexities towards the north; while, on September 6th, from the opposite point of the orbit, the same curves will reappear, only that they will now be convex towards the south. From March till June, and from September till December, the curvature is decreasing, while in the intervening periods corresponding changes take place in the opposite direction. We may describe these changes in a somewhat different way by saying that, on June 5th and December 6th both poles of the Sun are visible just on the edge of its disc; from June to December the north pole only is visible; and from December to June the south pole only can be seen.

If there were any direct method by which the Ecliptic could be determined at the telescope, the direction of the axis of the Sun would naturally be referred to it. It would then be found that on March 4th and September 6th the axis is at right angles to the plane of the Ecliptic, and that on June 5th and December 6th the axis makes with this plane an angle of 82° 45′, inclining in June to the west, and in December to the east.

Since, however, determinations of position angles are made with regard to the "parallel," or the direction of the apparent motion of a heavenly body (caused by the diurnal motion of the Earth), I have in this plate referred the position of the axis to this parallel. In each of the figures on the plate the point marked N is the north point of the disc, and E and W are the eastern and western points respectively.

By the "position angle of the Sun's axis," is meant the angle which the projection of the northern half of the Sun's axis on its apparent disc makes with the meridian passing through the Sun's centre, reckoned positive towards the eastern, and negative towards the western side of the disc. If the observation is made at noon, it is the angle which the direction of the axis makes with the vertical, when the image is viewed projected on a sheet of paper placed behind the eyepiece of an inverting telescope. If the observer's back be turned towards the Sun, the position angle will be positive when the upper half of the axis leans towards the right, and negative when it leans towards the left. On such a projection the cardinal points,

N., S., E., W., lie just as they do in an ordinary terrestrial atlas. On January 5th and July 6th, the position angle of the Sun's axis is Zero; from July 6th it gradually increases in a positive direction until it reaches its greatest value, viz.: + 26° 20′, on October 10th. From this date it gradually diminishes till January 5th, after which it becomes negative, reaching its greatest negative value, viz. − 26° 20′, on April 5th, and returning once more to Zero on July 6th.

Plates 19 to 22.

CHARTS FOR SUN SPOT OBSERVATIONS.

An observer who wishes to make a systematic study of the spots which appear from time to time on the Sun, will very soon feel the necessity for determining their positions on the Sun's disc, so as to thus recognise these markings when they reappear at its eastern limb, and be in a position to compare his observations with those of others. The latitude of a Sun spot is easily defined. The Sun's equator is the plane through the Sun's centre, perpendicular to the axis round which the Sun rotates, and the latitude of a Sun spot, north or south of the Sun's equator, is indicated in the same way, with regard to this plane, as the latitude of a place on the Earth with regard to the Earth's equator.

We use the meridian through Greenwich as a standard from which to measure terrestrial longitudes east and west. To determine longitudes on a body like the Sun, we must settle, first of all, as to what is to be the Sun's Greenwich. This is by no means easy. If there were any fixed object on the Sun, then of course we could take the meridian which passes through it, for the standard. But there is no fixed object, and we have to imagine one. At the moment of noon on January 1st, 1854 (which was the epoch selected by Carrington), suppose that a spike were driven into the Sun's equator, just at the ascending node. We reckon longitudes along the Sun's equator from the point thus defined.

In order to facilitate observation, Plates 19 to 22 inclusive have been drawn on the principle employed by Mr. Arthur Thomson, by the aid of which the heliographic latitude and longitude of a Sun spot may be determined within a single degree. The Plates exhibit the appearance which the Sun would present at different times of the year if lines of longitude and latitude up to 40° north and south were marked on its surface. The lines radiating from the sides give the direction of the parallel for the dates printed on them. The position for intermediate dates can be easily interpolated by the eye. The dates at the top and bottom of the Maps show the periods for which each is suitable, the heading which includes the date of observation being always kept uppermost. It would be advisable for the observer to prepare a tracing from the Plate showing the parallel for the day.

A light framework should be attached to the telescope, so as to support the plate or tracing at such a distance behind the eyepiece of the instrument that the image of the Sun may just fill the circle intended for it. The map should then be turned so as to allow a spot to travel along, or parallel to, the line which marks the position of the parallel on the date in question. Generally an equatorial telescope will have at the eyepiece a special 'line,' the image of which, as cast on the screen, sufficiently defines the parallel. When the image of the Sun exactly coincides with the circle, then read off the latitude and longitude from the map. The latitude is the heliographic latitude of the spot. The longitude, as read from the map, gives the difference in longitude between the spot and the centre of the disc. The longitude of the centre of the disc for noon on the 1st January of each year is given in the table on p. 20, and

the amount to be subtracted from this in order to find the longitude of the centre at noon on any given day of the year will be found in a table on p. 21. In leap years, one day must be added to the date after Feb. 28. Thus, on March 1st, 1896, we take out from the table the quantity corresponding to March 2nd. If the observation is not made at noon, an allowance must be made for the change in the longitude of the centre at the rate of $0^\circ{\cdot}55$ per hour.

By means of these two tables the longitude of the Sun's centre can be found at the time of observation.

If the spot is to the left of the centre, its longitude is greater than that of the centre of the disc, in which case we add the map-reading to the longitude obtained from the tables; if to the right, we subtract it. The result is the heliographic longitude of the spot referred to the prime meridian, which has been arbitrarily chosen as that which passed through the ascending node of the Equator at the beginning of the year 1854.

Example.—Suppose that at 4 P.M. on the 12th August, 1893, a spot is observed in the position of the letter A on Plate 22. The latitude is directly read off as $24^\circ{\cdot}0$ south. The difference of longitude between the spot and the centre is read $35^\circ{\cdot}0$. The longitude of the centre of the disc at noon on January 1st, 1893, is $290^\circ\ 9'$, from the table below. The quantity to be subtracted from this, corresponding to noon on the 12th August, is $64^\circ\ 32'$ (see next page). But since the observation is made at 4 P.M., we have to *increase* this by $0^\circ{\cdot}55 \times 4 = 2^\circ\ 12'$. We thus find the longitude of the centre of the disc at the time of observation to be

$$290^\circ\ 9' - [64^\circ\ 32' + 2^\circ\ 12'] = 290^\circ\ 9' - 66^\circ\ 44' = 223^\circ\ 25'$$

And since the spot is to the *left* of the centre, we have to *add* $35^\circ{\cdot}0$. We accordingly find, as the heliographic longitude of the spot, $258^\circ{\cdot}4$.

HELIOGRAPHIC LONGITUDE OF THE CENTRE OF SUN'S DISC.

Value of L for each Year.

Jan. 1. Greenwich Mean Noon.	L. °	L. ′
1892	80	52
3	290	9
4	152	36
5	14	56
6	237	23
7	86	41
8	309	7
9	171	34
1900	34	1
1	256	27
2	118	48

HELIOGRAPHIC LONGITUDE OF THE CENTRE OF SUN'S DISC.

Correction to L for Day of Year.

Date.	Subtract from L.		Date.	Subtract from L.		Date.	Subtract from L.		Date.	Subtract from L.	
	°	′		°	′		°	′		°	′
Jan. 1	0	0	April 1	105	36	July 5	281	53	Oct. 3	31	13
6	65	50	6	171	35	10	348	3	8	97	11
11	131	40	11	237	35	15	54	14	13	163	8
16	197	31	16	303	36	20	120	23	18	229	5
21	263	21	21	9	39	25	186	31	23	295	2
26	329	10	26	75	43	30	252	38	28	0	58
31	35	0	May 1	141	48	Aug. 4	318	45	Nov. 2	66	53
Feb. 5	100	50	6	207	54	9	24	52	7	132	48
10	166	41	11	274	1	14	90	58	12	198	44
15	232	31	16	340	9	19	157	3	17	264	39
20	298	22	21	46	17	24	223	7	22	330	34
25	4	13	26	112	27	29	289	10	27	36	27
Mar. 2	70	5	31	178	36	Sept. 3	355	13	Dec. 2	102	20
7	135	58	June 5	244	46	8	61	15	7	168	14
12	201	52	10	310	57	13	127	15	12	234	7
17	267	46	15	17	8	18	193	15	17	299	59
22	333	41	20	83	20	23	259	15	22	5	51
27	39	38	25	149	31	28	325	14	27	71	42
			30	215	41				32	137	32

CHAPTER III.—THE LUNAR MAPS.

PLACE OF THE MOON.

From the monthly maps 39—50 the positions of the Moon at different periods in the lunation can be learned. In the first place, it is to be noted that our Satellite lies always in or close to that part of the sky marked as the "Track of the Planets." When it is full the Moon is in opposition, and comes on the meridian at midnight, and hence we have the following rule:

Look out the monthly map for the month in question, then the full Moon lies in that part of the heavens where the "Track of the Planets" crosses the central meridian, already defined to be the line drawn on the map from the North point to the South point.

Example 1.—In what Constellation does the full Moon appear in September?

Solution.—The answer is given by Plate 47, where the Track of the Planets crosses the central meridian in Pisces, which indicates the required position.

Example 2.—When is the full Moon near the Pleiades?

Solution.—Plate 49 shows the Pleiades on the central meridian, and accordingly November is the answer to the question.

To find the position of the Moon at the time of the first quarter, the following is the method.

Look out the monthly map for three months *preceding* the given date, then the constellation in or near which the Moon lies at the first quarter is shown at the intersection of the Track of the Planets with the central meridian.

Example.—In what constellation does the first quarter Moon appear in June?

Solution.—The map three months earlier is Plate 41 for March. This shows the intersection of the Track of the Planets and the central meridian in Virgo, which is accordingly the answer required.

To find the position of the Moon at the time of the last quarter, the following is the method.

Look out the monthly map for three months *following* the given date, then the Constellation in or near which the Moon lies at the last quarter is shown at the intersection of the Track of the Planets with the central meridian.

Example.—In what constellation does the last quarter Moon appear in July?

Solution.—The map three months later is Plate 48, which shows that the constellation is Aries.

It ought to be observed that, on account of the rapid motion of the Moon, only a rough indication of its place can be expected from the process here given, and that the accuracy will be greater the nearer the phase in question happens to the middle of the month.

The foregoing problems can also be solved by the more general method now to be described. The Table of Moon Age shows the position in the heavens which the Moon occupies at any age in any month. The use of this Table is as follows.

Enter the Table in the vertical column bearing the name of the month. Then take the age in that column nearest the given age, and the figure at the left on the same row gives the number of the monthly map in which the region where the Moon is situated lies on the "central meridian" where the "Track of the Planets" crosses it.

THE TABLE OF MOON AGE.

Map.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
39	14	12	10	7	5	3	29	25	23	20	18	16
40	17	14	12	10	7	5	3	27	25	23	21	19
41	19	16	15	12	10	8	5	2	28	25	23	21
42	22	19	17	14	12	10	8	5	1	0	26	24
43	25	22	21	16	14	12	10	7	4	2	28	26
44	27	25	23	18	16	14	11	9	7	4	2	29
45	29	27	25	20	18	16	14	11	9	7	5	2
46	2	0	27	25	21	18	16	14	11	9	7	4
47	5	2	29	27	24	20	18	16	14	11	10	7
48	7	4	3	0	27	23	20	18	16	14	12	9
49	10	7	5	3	0	27	23	20	18	16	14	11
50	12	9	8	5	2	0	27	23	20	18	16	14

Example 1.—Where does the Moon lie when four days old in October?

Solution.—The October column in the Table of Moon Age being referred to, the sixth figure from the top gives 4, the age of the Moon, and the figure at the end of that row on the left is 44. This monthly map shows that the Moon must then be in or near Sagittarius.

Example 2.—What will be the age of the Moon when on the meridian at 10 P.M. in August?

Solution.—At 10 P.M. in August, the heavens will be as in Plate 45. Therefore we refer to the row for Map 45 in the Table of Moon Age, which shows, under the column August, that the Moon must then be about 11 days old.

Example 3.—Determine when the Moon, at the first quarter, has a specially high altitude.

Solution.—The heavens must be as in Plate 49, which refers us to the last row but one of the Table. For the Moon to be 7 days old we look under the column February, in which month the heavens are as in Plate 49 about 6 P.M.

Plates 23 to 38.

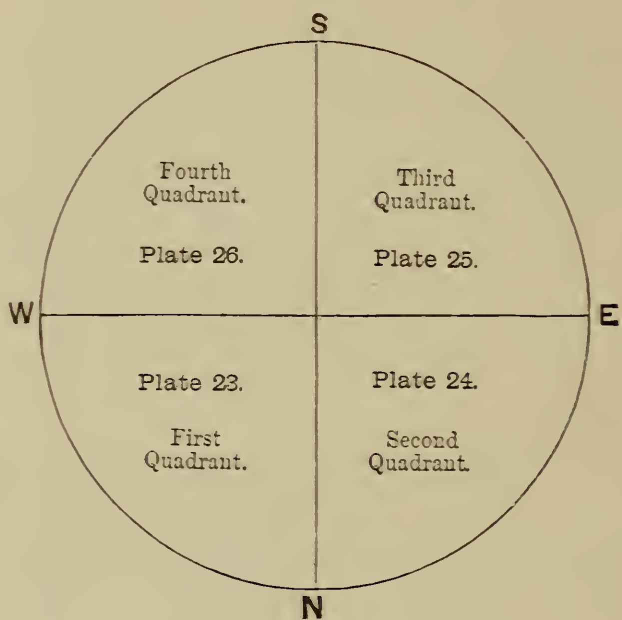
THE LUNAR OBJECTS.

For the study of the Lunar formations, Plates 23 to 38 have been specially drawn.

As the astronomical telescope shows the Moon turned upside down, and with right and left interchanged, the maps of our Satellite are represented accordingly. The four quadrants (Plates 23, 24, 25, 26) are designated in the manner shown in the annexed figure. For observations of the Moon, the "terminator" or boundary between light and shade, is the place where the objects are best seen, and Plates 23—38 of the present Atlas have been arranged to facilitate observation of the Lunar formations on the terminator at various ages, from new to full. The terminators for each day of a lunation are marked on the quadrants; the morning terminator being that when the Sun is rising on the object in question. The quadrants also enable the latitudes and longitudes of Lunar objects to be found.

Terminology of Lunar Quadrants.

Moon in Inverting Telescope.



As the Moon is so much more conveniently observed from new to full, than from full to new, it is the former series of changes that have been more particularly provided for. The telescopic view of the Crescent Moon, 3 days old, is shown in Plate 27. On the opposite page an index outline is given on which each of the formations receives a special number or letter. The name of the formation may be found by looking out the number or letter in the Catalogue of Lunar formations; but for greater convenience in reference, the names of the chief objects visible in each phase are set out on the Index outline as well. As the Moon grows day by day, the terminator changes, and an ever varying series of objects are presented. A special Plate is therefore given for each day of the Moon's age, from the 3rd up to the 14th, when the Moon is full. Before the third day the Moon is so close to the Sun that observations cannot be made with advantage.

Suppose, for instance, that the Moon is 9 days old. The observer then refers to Plate 33. On the terminator, a little below the middle, he notes a fine crater, and desires to learn its name. The Index outline assigns the Number 380, and the list on the margin shows that this feature is named "Copernicus." The observer will be able to trace the same object with lessening detail up to the time of Full Moon. See Plates 34 to 38. From the comparison of any one of these Plates with the figure on this page, it appears that Copernicus must lie

in the "Second Quadrant" or on Plate 24, where the great crater will be found again as No. 380, a conspicuous object at 20° East longitude, and 10° North latitude. Along the top of Plate 24 are shown the positions of the terminators at corresponding ages of the Moon. It will be noted that the morning terminator on the 9th day passes through Copernicus. So also does the evening terminator on the 24th, so that if the observer desires to study Copernicus when illuminated by the sunlight from the opposite side, he may repeat his observation 15 days later.

As another illustration, let us suppose the Moon to be 4 days old, and that after comparing the Moon with Plate 28 we desire to know the name of that large round dark patch, a little below the centre, which lies midway between the limb and the terminator. The Index outline shews it marked A, and from the reference to the margin or to the Catalogue the object is identified as the Mare Crisium. It is represented in Plate 23 as A. near the top at the left.

To show the mode of representing the ranges of Lunar mountains, we may suppose the student to be looking at the Moon a little after the first quarter, say on the eighth day, as on Plate 32. He notices a remarkable formation a little below the centre. The Index outline labels this object *c*, and the margin shows that we are looking at the lunar Apennines. Plate 24 exhibits the Apennines pointing towards Copernicus.

Suppose that a view of some particular formation of known name be specially desired, the process is as follows. Look it out in the Index at the end of this volume, the first reference is to the quadrant, and the next is to the plate where the object is represented on the terminator.

Thus, for instance, to find the position of Plato. The Index shows first of all that it lies on Plate 24, that is, in the Second Quadrant. The next reference is to Plate 32, which shows the object lying near the terminator when the Moon is 8 days old. There are further references to 33, 34, and 35, where the object is also visible. The evening terminator on Plate 24 shows that when this object is suitably placed for observations with the opposite illumination, the Moon is about 23 days old. The subsequent references in the Index are to those pages of the Introduction in which the object is mentioned.

The beginner should, however, be apprized that even with the assistance which it is hoped that these maps will afford him, considerable pains are often required to identify the lunar objects. In the first place, the position of the Moon shifts slightly, thus producing what is called libration. It therefore follows that the hemisphere turned towards us varies somewhat. The maps are accommodated to a state of mean libration, and the student must not be surprised if he finds an object sometimes higher and sometimes lower than its position in the map would have led him to expect. These changes often produce considerable variations in the appearance of the lunar formations. It must also be remembered that the age of the Moon cannot be always exactly that of the map which comes nearest to it. This will often involve considerable alterations in the appearance of the lunar formations from those which they present at the exact phase which the map depicts. The elucidation of the several points which thus arise will afford much interesting occupation, and will, it is hoped, lead the student to a close acquaintance with the beautiful scenery of our Satellite.

CATALOGUE OF LUNAR OBJECTS.

Figures refer to the Number of the Crater or similar formation, capital letters refer to the so-called "Seas," and small letters refer to the Mountain Ranges and isolated Mountains.

1 Langrenus.
2 Kästner.
3 Vendelinus.
4 Maclaurin.
5 Hecatæus.
6 Ansgarius.
7 Petavius.
8 Wrottesley.
9 Palitzch.
10 Hase.
11 Legendre.
12 W. Humboldt.
13 Phillips.
14 Furnerius.
15 Stevinus.
16 Snellius.
17 Adams.
18 Marinus.
19 Fraunhofer.
20 Oken.
21 Vega.
22 Pontécoulant.
23 Biela.
24 Hagecius.
25 Boussingault.
26 Boguslawsky.
27 Schomberger.
28 Webb.
29 Messier.
30 Lubbock.
31 Godenius.
32 Guttemberg.
33 Magelhaens.
34 Colombo.
35 Cook.
36 Santbech.
37 McClure.
38 Crozier.
39 Bellot.
40 Borda.
41 Reichenbach.
42 Rheita.
43 Neander.
44 Metius.
45 Fabricius.
46 Janssen.
47 Steinheil.
48 Vlacq.
49 Rosenberger.
50 Nearchus.
51 Hommel.
52 Pitiscus.
53 Mutus.
54 Manzinus.
55 Censorinus.
56 Torricelli.
57 Capella.
58 Isidorus.
59 Mädler.
60 Bohnenberger.
61 Rosse.
62 Fracastorius.
63 Piccolomini.
64 Stiborius.
65 Riccius.
66 Rabbi Levi.
67 Zagut.
68 Lindenau.
69 Nicolai.
70 Büsching.
71 Buch.
72 Hypatia.
73 Delambre.
74 Theon Senr.
75 Theon Junr.
76 Taylor.
77 Alfraganus.
78 Kant.
79 Theophilus.
80 Cyrillus.
81 Catharina.
82 Tacitus.
83 Beaumont.
84 Descartes.
85 Abulfeda.
86 Almanon.
87 Geber.
88 Abenezra.
89 Azophi.
90 Sacrobosco.
91 Fermat.
92 Polybius.
93 Pons.
94 Pontanus.
95 Gemma Frisius.
96 Poisson.
97 Aliacensis.
98 Werner.
99 Apianus.
100 Playfair.
101 Blanchinus.
102 La Caille.
103 Delaunay.
104 Faye.
105 Donati.
106 Airy.
107 Argelander.
108 Parrot.
109 Albategnius.
110 Hipparchus.
111 Halley.
112 Hind.
113 Horrocks.
114 Rhœticus.
115 Réaumur.
116 Walter.
117 Nonius.
118 Fernelius.
119 Stöfler.
120 Faraday.
121 Maurolycus.
122 Barocius.
123 Clairaut.
124 Licetus.
125 Cuvier.
126 Bacon.
127 Jacobi.
128 Lilius.
129 Zach.
130 Kinau.
131 Pentland.
132 Curtius.
133 Simpelius.
134 Miller.
135 Schubert.
136 Apollonius.
137 Firmicus.
138 Azout.

CATALOGUE OF LUNAR OBJECTS—*continued.*

139 Neper.
140 Condorcet.
141 Behaim.
142 Lapeyrouse.
143 Hanno.
144 Le Gentil
145 Tannerus.
146 Huggins.
147 Timoleon.
148 Zeno.
149 Schwabe.
150 Hansen.
151 Alhazen.
152 Picard.
153 Pierce.
154 Taruntius.
155 Secchi.
156 Proclus.
157 Maskelyne.
158 Jansen.
159 Vitruvius.
160 Maraldi.
161 Cauchy.
162 Emmart.
163 Oriani.
164 Plutarch.
165 Seneca.
166 Macrobius.
167 Cleomedes.
168 Tralles.
169 Burckhardt.
170 Hahn.
171 Berosus.
172 Gauss.
173 Geminus.
174 Bernouilli.
175 Messala.
176 Berzelius.
177 Hooke.
178 Schumacher.
179 Struve.
180 Mercurius.
181 Franklin.
182 Cepheus.
183 Oersted.
184 Shuckburgh.
185 Chevallier.
186 Atlas.
187 Hercules.
188 Endymion.
189 De la Rue.
190 Strabo.
191 Thales.
192 Gärtner.
193 Democritus.
194 Arnold.
195 Moigno.
196 Peters.
197 Meton.
198 Euctemon.
199 Challis.
200 Main.
201 Giòja.
202 Scoresby.
203 Barrow.
204 W. C. Bond.
205 Christian Mayer.
206 Archytas.
207 Aristoteles.
208 Eudoxus.
209 Alexander.
210 Egede.
211 Great Alpine Valley.
212 Grove.
213 Mason.
214 Plana.
215 Bürg.
216 Baily.
217 Daniell.
218 Posidonius.
219 Chacornac.
220 Le Monnier.
221 Römer.
222 Bond.
223 Maury.
224 Littrow.
225 Newcomb.
226 Dawes.
227 Plinius.
228 Ross.
229 Maclear.
230 Sosigenes.
231 Julius Cæsar.
232 Boscovich.
233 Taquet.
234 Menelaus.
235 Sulpicius Gallus.
236 Bessel.
237 Linné.
238 Aratus.
239 Conon.
240 Manilius.
241 Ukert.
242 Triesnecker.
243 Hyginus.
244 Agrippa.
245 Godin.
246 Ritter.
247 Sabine.
248 Dionysius.
249 Manners.
250 Arago.
251 Ariadæus.
252 Silberschlag.
253 De Morgan.
254 Cayley.
255 Whewell.
256 Calippus.
257 Theætetus.
258 Cassini.
259 Aristillus.
260 Autolycus.
261 Mösting.
262 Lalande.
263 W. Herschel.
264 Ptolemæus.
265 Alphonsus.
266 Arzachel.
267 Alpetragius.
268 Lassell.
269 Davy.
270 Gueriké.
271 Parry.
272 Bonpland.
273 Fra Mauro.
274 Thebit.
275 Straight Wall.
276 Birt.
277 Purbach.
278 Regiomontanus.
279 Hell.
280 Pitatus.
281 Hesiodus.
282 Gauricus.
283 Wurzelbauer.
284 Sasserides.
285 Ball.
286 Lexell.
287 Nasireddin.
288 Orontius.

CATALOGUE OF LUNAR OBJECTS—*continued.*

289 Pictet.
290 Saussure.
291 Tycho.
292 Heinsius.
293 Wilhelm I.
294 Longomontanus.
295 Street.
296 Maginus.
297 Deluc.
298 Clavius.
299 Cysatus.
300 Moretus.
301 Short.
302 Newton.
303 Gruemberger.
304 Cabeus.
305 Casatus.
306 Klaproth.
307 Wilson.
308 Kircher.
309 Bettinus.
310 Zuchius.
311 Segner.
312 Blancanus.
313 Scheiner.
314 Weigel.
315 Rost.
316 Bailly.
317 Schiller.
318 Bayer.
319 Pingré.
320 Hansen.
321 Phocylides.
322 Wargentin.
323 Schickard.
324 Drebbel.
325 Inghirami.
326 Hainzel.
327 Lehmann.
328 Lacroix.
329 Piazzi.
330 Lagrange.
331 Fourier.
332 Vieta.
333 Doppelmayer.
334 Lee.
335 Vitello.
336 Clausius.
337 Capuanus.
338 Cichus.
339 Mercator.
340 Campanus.
341 Kies.
342 Bullialdus.
343 Lubiniezky.
344 Nicollet.
345 Hippalus.
346 Agatharchides.
347 Gassendi.
348 Herigonius.
349 Letronne.
350 Mersenius.
351 Cavendish.
352 Byrgius.
353 Eichstädt.
354 De Vico.
355 Ramsden.
356 Billy.
357 Hansteen.
358 Sirsalis.
359 Fontana.
360 Zupus.
361 Crüger.
362 Rocca.
363 Grimaldi.
364 Damoiseau.
365 Riccioli.
366 Lohrmann.
367 Hermann.
368 Flamsteed.
369 Wichmann.
370 Euclides.
371 Landsberg.
372 Gambart.
373 Sömmering.
374 Schröter.
375 Pallas.
376 Bode.
377 Reinhold.
378 Hortensius.
379 Milichius.
380 Copernicus.
381 Stadius.
382 Eratosthenes.
383 Gay Lussac.
384 Tobias Mayer.
385 Kunowsky.
386 Encke.
387 Kepler.
388 Bessarion.
389 Reiner.
390 Marius.
391 Hevel.
392 Cavalerius.
393 Olbers.
394 Cardanus.
395 Krafft.
396 Vasco de Gama.
397 Seleucus.
398 Marco Polo.
399 Archimedes.
400 Beer.
401 Timocharis.
402 Lambert.
403 Pytheas.
404 Euler.
405 Diophantus.
406 Delisle.
407 Caroline Herschel.
408 Carlini.
409 Leverrier.
410 Helicon.
411 Kirch.
412 Piazzi Smyth.
413 Plato.
414 Timæus.
415 Birmingham.
416 Epigenes.
417 Goldschmidt.
418 Anaxagoras.
419 Fontenelle.
420 Philolaus.
421 Anaximenes.
422 J. J. Cassini.
423 Condamine.
424 Maupertuis.
425 Bianchini.
426 Sharp.
427 Mairan.
428 Foucault.
429 Harpalus.
430 J. F. W. Herschel.
431 Anaximander.
432 Pythagoras.
433 South.
434 Babbage.
435 Œnopides.
436 Robinson.
437 Cleostratus.
438 Xenophanes.

CATALOGUE OF LUNAR OBJECTS—*continued.*

439 Repsold.
440 Harding.
441 Gerard.
442 Lavoisier.
443 Ulugh Beigh.
444 Lichtenberg.
445 Briggs.
446 Otto Struve.
447 Aristarchus.
448 Herodotus.
449 Wollaston.
450 Schiaparelli.
451 Gruithuisen.
452 Brayley.
453 Galileo.
454 Horrebow.

MOUNTAIN RANGES AND ISOLATED MOUNTAINS.

a Alps.
b Caucasus.
c Apennines.
d Carpathians.
e Sinus Iridum Highlands.
f Hæmus.
g Pyrenees.
h Altai.
i Riphæan Mountains.
j Lahire.
k Taurus.
l Teneriffe Range.
m Straight Range.
n Percy Mountains.
o Harbinger Mountains.
p Hercynian Mountains.
q Pico.
r Piton.
s Mt. Argæus.
t Mt. Hadley.
u Laplace Promontory.
v Mt. Huygens.
w Mt. Bradley.

Mountains near the Limb:—

D'Alembert Mts.—on the east limb, extending from S. lat. 19° to N. lat. 12°.
The Cordilleras—near the east limb, extending from S. lat. 23° to S. lat. 8°.
The Rook Mountains—on the east limb, extending from S. lat. 39° to S. lat. 16°.
The Doerfel Mountains—on the south-east limb, extending from S. lat. 80° to S. lat. 57°.
The Leibnitz Mountains extend from S. lat. 70° on the west limb to S. lat. 80° on the east limb.
Humboldt Mountains—on the west limb, extending from N. lat. 72° to N. lat. 53°.

MARIA OR SEAS.

A Mare Crisium.
B „ Fœcunditatis.
C „ Australe.
D „ Humboldtianum.
E „ Tranquillitatis.
F „ Nectaris.
G Lacus Somniorum.
H „ Mortis.
J Mare Serenitatis.
K „ Frigoris.
L „ Imbrium.
M „ Vaporum.
N Sinus Æstuum.
P „ Medii.
Q Mare Nubium.
R Sinus Iridum.
S Oceanus Procellarum.
T Mare Humorum.
V Palus Somnii.
W Sinus Roris.
X Palus Nebularum.
Y Mare Smythii.
Z Palus Putredinis.

CHAPTER IV.—THE MONTHLY MAPS.

Plates 39—50.

The diurnal rotation of the earth gives rise to an apparent revolution of the celestial sphere in a period of one sidereal day. In consequence of this movement the appearance of the sky is continually changing, so that to the beginner it is often a matter of considerable difficulty to know where to look for any particular star or constellation.

As the sidereal day is about 4 minutes shorter than the ordinary mean solar day, the effect produced is a gradual shifting of the stars from east to west,—a star which occupies a certain position one night, reaches the same position 4 minutes earlier the next night, so that at the end of a month this position is attained 2 hours earlier than at the beginning.

In order to render these changes easier to follow, and to enable the student to identify the principal constellations without difficulty, and to know where any particular star or group of stars is to be found at any time, Plates 39—50 are used. They represent the positions of the principal stars down to the 4th magnitude at intervals of 2 sidereal hours. The first shows the aspect of the heavens at midnight on January 15th, the sidereal time then being 7h. 37m. This map will also represent the appearance of the visible hemisphere at the times shown in the corners at the top. Thus we find that the first of the monthly maps may be used in February at 10 P.M., in March at 8 P.M. From April to September inclusive, the stars will occupy the positions here indicated during the daylight hours, when they will be invisible ; but in October this aspect of the sky may again be seen at 6 A.M., in November at 4 A.M., and in December at 2 A.M. To find the right map for any month and hour we can make use of the following Table.

TABLE TO FIND THE ASPECT OF THE HEAVENS AT ANY GIVEN MONTH AND HOUR OF NIGHT.

	P.M. 4h.	P.M. 6h.	P.M. 8h.	P.M. 10h.	Mid-night. 12h.	A.M. 2h.	A.M. 4h.	A.M. 6h.	A.M. 8h.
January....	47	48	49	50	39	40	41	42	43
February ..		49	50	39	40	41	42	43	
March		50	39	40	41	42	43	44	
April			40	41	42	43	44		
May			41	42	43	44	45		
June			42	43	44	45	46		
July.........			43	44	45	46	47		
August			44	45	46	47	48		
September.		44	45	46	47	48	49	50	
October.....		45	46	47	48	49	50	39	
November..	45	46	47	48	49	50	39	40	41
December..	46	47	48	49	50	39	40	41	42

Examples of the Use of this Table:

I. To find the map suitable for 10 P.M. in March. Take the third row, and under 10 P.M. is found 40. This means Plate 40.

II. What map should be used at 7-30 P.M. in November? On the eleventh row we find 47 under 8 P.M., and as 7-30 is nearer to 8 than to 6, we accordingly choose Plate 47.

It will of course be understood that the maps have been designed to represent the appearance of the sky on the 15th of each month, at the hours mentioned. The changes are, however, so slow, that for most purposes they will be found sufficiently applicable to the whole month. If, however, greater precision is desired, it can be obtained by *subtracting* half-an-hour from the time given on the map for each week *after*, or *adding* half-an-hour for each week *before* the middle of the month. Plate 39 is thus quite accurate at 11 P.M. on the 30th of January, or at 8-30 P.M. on March 8th; similarly Plate 41 is correct at 5 A.M. on the 30th December, or at 11 P.M. on the 1st April.

These maps have been constructed for the latitude 53° 23′ N. They will thus be suitable for all parts of the British Isles. The bounding circle represents the horizon, and the small cross at the centre marks the position of the zenith. The projection used is such that the distance of each star from the centre of the map is proportional to the star's zenith distance. The angle which the line joining a star to the zenith makes with the central meridian is the azimuth of the star.

As the celestial sphere is viewed from the inside, the cardinal points are not disposed on these maps as in a terrestrial atlas. In the present case, when the north is at the top, the west will be on the right, and the east on the left.

If we wish to compare any region of the sky with the map, we suppose a radius drawn through the middle of this region, and the point where it cuts the circumference of the map gives us the azimuth. Turning our face towards this point of the compass, we hold the map so that the corresponding point of the circumference is lowest, and, remembering that the centre of the circle represents the zenith, we have on the map a picture of the corresponding position of the sky. For instance, if we wish to find the constellation Leo at midnight, in the middle of March, we find from Map 41 that the radius drawn through the middle of it cuts the circumference at about $\frac{2}{5}$ths of the way from south towards west. We accordingly turn to that point of the horizon, and we can readily find this constellation. The brightest star, Regulus, will be then almost exactly half-way between the zenith and horizon, or at an altitude of 45°, while the "Sickle," which forms the fore-part of this constellation, will be found tilted over towards the west. If we turn a little further towards the west, we shall find the two bright stars, Castor and Pollux, a little lower in the sky, the line joining them being nearly horizontal. Again, if in October, at 10 P.M., we wish to examine "The Plough," as the group formed by the principal stars in Ursa Major are called, we go to Plate 47 and find this group almost due north. We have accordingly to turn the map upside down, so as to bring the north point lowest, and we then see this figure stretching across the sky in a horizontal direction, at an altitude of about 20°. If we turn to the north-east, we again find Castor and Pollux just above the horizon, but this time the line joining them is very nearly vertical.

The names of the constellations have been printed on the maps, so that when the maps are held in the proper position for any constellation its name may be erect.

As the student becomes more familiar with the stars, he will probably wish to identify many fainter groups that do not appear on these plates. In order to enable this to be done

with facility, the faint dotted lines have been inserted which mark the boundaries of the regions which each of the plates, 51—70, of the general Atlas, cover on the sky. These lines appear everywhere in pairs, the spaces between the pairs being the areas by which the maps overlap each other. The numbers within the regions thus marked out are those of the corresponding plates in this volume, where more detailed maps of the same part of the sky will be found. Thus in Plate 40 we find the constellation Leo almost wholly contained in the space corresponding to Plate 60, and some of its principal stars in the space common to Plates 54, 55, and 60. If we turn to Plate 60 we shall find the whole group on a much larger scale, while 54 and 55 show the more northern parts of this constellation.

CHAPTER V.—THE INDEX TO THE PLANETS.

It is a special object of this work to facilitate observation of the principal planets. Let it be once for all understood that those who want *exact* positions must seek elsewhere for them. What is here given is only an index to the planets generally, sufficient for the following purposes :—

(1) To find the position on the heavens which each principal planet occupies.

(2) To find when any principal planet rises or souths or sets.

(3) To determine the best season during any year for the observation of any principal planet.

(4) To ascertain the name of any principal planet when the time and place of its appearance are known.

The foundation of the Index to Planets, up to A.D. 1902, is given in the following table, which contains the "Planetary Phenomena" as described at the head of each column.

PLANETARY PHENOMENA.

1	2	3	4	5	6	7	8	
A.D.	Mercury, Evening Star.	Mercury, Morning Star.	Venus, Evening Star. Greatest Elongation E.	Venus, Morning Star. Greatest Elongation W.	Mars in Opposition.	Jupiter in Opposition.	Saturn in Opposition.	No. of Phase of Saturn. See Plate 8.
1892	Mar. 27—Apr. 3	Sept. 7-14	April	September	August	October	March	3
1893	Mar. 11-18	Aug. 23-30	December	—	—	November	March	3
1894	Feb. 23—Mar. 2	Aug. 6-13	—	April	October	December	April	4
1895	Feb. 6-13	Nov. 7-14	July	November	—	—	April	4
1896	Jan. 19-26	Oct. 22-29	—	—	December	January	May	5
1897	Apr. 25—May 2	Oct. 5-12	February	July	—	February	May	5
1898	Apr. 8-15	Sept. 18-25	September	—	—	March	May	5
1899	Mar. 22-29	Sept. 2-9	—	February	January	April	June	6
1900	Mar. 5-12	Aug. 16-23	April	September	—	May	June	6
1901	Feb. 16-23	July 29—Aug. 5	December	—	February	June	July	7
1902	Jan. 30—Feb. 6	Oct. 31—Nov. 7	—	April	—	August	July	7

MERCURY.

The first column of the Table of Planetary Phenomena gives the year A.D.; the 2nd column gives a period of a week during the early months of the year, when Mercury may be looked for as an Evening Star, low in the west, soon after sunset. The 3rd column gives a

period of a week in Autumn, when Mercury may be looked for as a Morning Star, low down in the east, before sunrise. There are, of course, other times when this planet may be observed, but in the present work it is not necessary to give further information.

VENUS.

The 4th column of the Table of Planetary Phenomena gives the month in which Venus attains the greatest elongation East, *i.e.*, is at the greatest apparent distance east from the Sun. As already stated, p. 7, this planet attains its greatest brilliancy as an Evening Star in about a month, or rather longer, after reaching the phase mentioned. For example:—In the year 1895, it appears that Venus will have its greatest elongation east in July, and the planet is brightest as an Evening Star about August.

The 5th column of the Table of Planetary Phenomena gives the month in which Venus has the greatest elongation west. It attains its greatest brilliancy as a Morning Star about a month, or rather more, before the phase now mentioned is attained. For example:—In the year 1900, Venus attains its greatest elongation west in September, and the planet is brightest as a Morning Star in August of that year.

INDEX TO VENUS.

A.D.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1892	46	47	48	49	39	39	39	39	40	41	42	43
1893	44	46	47	48	49	50	40	41	42	43	45	46
1894	46	46	46	47	48	49	50	39	40	42	43	44
1895	45	47	48	49	50	40	41	41	41	41	41	42
1896	44	45	46	47	49	50	39	40	42	43	44	45
1897	47	48	48	49	48	49	49	39	40	41	42	43
1898	45	45	47	49	50	40	41	42	43	43	43	43
1899	44	45	46	47	48	49	50	40	41	42	44	45
1900	46	47	49	50	50	50	50	39	40	41	42	43
1901	44	46	47	48	49	39	40	41	42	43	45	46
1902	46	46	46	47	48	49	50	39	40	41	43	44

The Index to Venus, by which title we have designated the preceding table, enables the position of the planet to be readily ascertained for any month up to the end of 1902. It must be remembered that, as the unit of time adopted in this index, as well as in those of the other planets, is a month, and as the locality can only be indicated by dividing the Track of the Planets around the heavens into twelve portions, no close precision need be looked for. No doubt in the great majority of cases the map named in the index will be that where the central meridian lies nearest the planet. In other words, the place of the planet is given to within an hour. It may, however, happen in extreme conditions that the map indicated is not the best one, but in such cases the right map always lies next to that to which the index refers. Even when this happens, the purposes of the index are not frustrated, for the planet will lie so near to the position in question, that its identification will be unmistakable, unless on the rare occasions when two planets happen to lie close together.

At the top of the "Index to Venus" the names of the months are given in a horizontal row. The vertical column on the left gives the year A.D. The index shows a certain number corresponding to each month and year; this number refers to one of the monthly maps. The planet lies at the region, on this map, where the central meridian cuts the "Track of the Planets." The use of the index is extremely simple, and we proceed to illustrate it by a few examples.

Examples to Illustrate the Use of the Index to Venus.

Example 1.—Where is the planet Venus situated in October, 1893?

Solution.—The "index to Venus" for the month of October in the year 1893, refers to Map 43. The central meridian cuts the Track of the Planets between Libra and Scorpio, that is accordingly the position of Venus; and a comparison with Map 45 shows that this portion of the heavens sets at 6 P.M. in October, so that the planet will probably not be seen.

Example 2.—Where does Venus lie in June, 1894?

Solution.—The index refers to Plate 49. The "Track of the Planets" cuts the central meridian close to the Pleiades, so that Venus is in that vicinity at the time named; and since Map 41 shows that the Pleiades set during the daylight hours in June, it will be useless to look for the planet at this time.

Example 3.—Where will Venus lie at greatest elongation East in 1897?

Solution.—The phase named is attained in February, the Index refers to Map 48, whence the position of the planet is near Aries.

MARS.

We have already explained the different appearances presented by Mars in connection with Plate 8. We are now to illustrate the use of the Index to Mars, by which the position of the planet at all dates up to A.D. 1902 can be determined with sufficient approximation. The structure of the index is on the same principle as that of the index to Venus, and its use will be shown by examples.

INDEX TO MARS.

A.D.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1892	43	44	44	45	45	46	46	46	46	46	46	47
1893	48	48	49	50	50	39	40	40	41	41	42	43
1894	43	44	45	46	46	47	48	48	48	48	48	48
1895	48	48	48	49	50	50	39	40	40	41	42	42
1896	43	44	44	45	46	47	47	48	49	49	50	50
1897	50	50	50	39	39	40	41	41	42	42	43	44
1898	45	46	46	47	48	49	49	50	39	39	40	40
1899	39	39	39	39	40	40	41	42	42	43	44	44
1900	45	46	47	48	48	49	50	39	39	40	40	41
1901	41	40	40	40	40	41	41	42	43	43	44	45
1902	46	46	47	48	49	49	50	39	40	40	41	41

Examples to Illustrate the Use of the Index to Mars.

Example 1.—Find the place of Mars in February, 1894.

Solution.—The index shows Plate 44. This locates Mars in Sagittarius or Scorpio, and the planet comes on the meridian in daylight.

Example 2.—When is Mars on the meridian in January, 1898?

Solution.—The index refers to Plate 45, which shows that Mars is in Sagittarius, and the Table in the left-hand corner of the Plate shows that in January this constellation souths at noon. It may be remarked that, when twelve or thirteen months from opposition, Mars always culminates about noon.

Example 3.—Where is Mars situated in the opposition of 1896?

Solution.—The Table of Planetary Phenomena shows the opposition to be in December. The Index refers to Map 50, so the planet is situated over Orion.

JUPITER.

The great planet moves over the heavens so that the oppositions usually succeed each other at intervals of 13 months. The Index to Jupiter is arranged in the same manner as those of Venus and Mars.

INDEX TO JUPITER.

A.D.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1892	47	47	47	47	48	48	48	48	48	48	48	48
1893	48	48	48	48	49	49	49	49	49	49	49	49
1894	49	49	49	49	49	50	50	50	50	50	50	50
1895	50	50	50	50	50	39	39	39	39	39	39	39
1896	39	39	39	39	39	39	40	40	40	40	40	40
1897	40	40	40	40	40	40	40	41	41	41	41	41
1898	41	41	41	41	41	41	41	41	42	42	42	42
1899	42	42	42	42	42	42	42	42	42	43	43	43
1900	43	43	43	43	43	43	43	43	43	43	44	44
1901	44	44	44	44	44	44	44	44	44	44	44	45
1902	45	45	45	45	45	45	45	46	46	46	46	46

Examples to Illustrate the Use of the Index to Jupiter.

Example 1.—When will Jupiter be in opposition in the year 1900, and in what part of the heavens will the planet then lie?

Solution.—The Table of Planetary Phenomena, column 7, shows that Jupiter will be in opposition in May, 1900. The "Index to Jupiter" for this date gives Plate 43, which shows that Jupiter will then be about Scorpio or Libra; and since Map 41 shows this part of the sky on the eastern and Map 45 shows it on the western horizon, it follows that the planet may be seen from about 8 P.M. till 4 A.M. during the given month.

Example 2.—At what oppositions will Jupiter rise highest in the heavens at culmination?

Solution.—Plates 39—50 show that the most northern part of the "Track of the Planets" lies a little to the west of Gemini, and that it is on the meridian in December at midnight. A planet in opposition crosses the meridian at midnight. Hence Jupiter will be highest when opposition occurs in December, as, for example, in 1894.

Example 3.—About what time does Jupiter rise in March, 1899?

Solution.—The Index refers to Map 42, showing that the planet is in Virgo, and Map 39 shows that this constellation rises in March about 8 P.M.

SATURN.

The index to Saturn is used in the same manner as the indexes to the other planets already described.

INDEX TO SATURN.

A.D.	Jan.	Feb.	Mar.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
1892	41	41	41	41	41	41	41	41	41	41	42	42
1893	42	42	42	41	41	41	41	42	42	42	42	42
1894	42	42	42	42	42	42	42	42	42	42	42	42
1895	42	42	42	42	42	42	42	42	42	42	43	43
1896	43	43	43	43	43	43	43	43	43	43	43	43
1897	43	43	43	43	43	43	43	43	43	43	43	43
1898	43	43	43	43	43	43	43	43	43	43	43	44
1899	44	44	44	44	44	44	44	44	44	44	44	44
1900	44	44	44	44	44	44	44	44	44	44	44	44
1901	45	45	45	45	45	45	45	45	45	45	45	45
1902	45	45	45	45	45	45	45	45	45	45	45	45

Examples to Illustrate the Use of the Index to Saturn.

Example 1.—When is Saturn in opposition in 1894, and in what part of the heavens does it then lie?

Solution.—The opposition is in April, and the index to Saturn gives Plate 42. The locality is near Virgo, and the phase No. 4, Plate 8.

Example 2.—Where is Saturn in August, 1901?

Solution.—The index refers to Plate 45, showing that Saturn is about Sagittarius or Capricornus. As the opposition in this year is in July, the phase shown by Saturn is No. 7 on Plate 8.

Example 3.—When does Saturn set in August, 1898?

Solution.—The Index refers to Map 43, showing that Saturn is in Libra, and Plate 45 shows this constellation setting at 10 P.M. in August.

THE NAMING OF AN UNKNOWN PLANET.

The beginner will sometimes notice a bright star-like object which he knows is not a Star, for it is not represented on the maps. He infers that it must be a planet, and he desires to find its name.

It may be assumed that the object must be one of the four bodies—Venus, Mars, Jupiter, or Saturn. With the aid of the Planetary Index it is a simple matter to determine which of the four the unknown object must be.

To illustrate the process by an example, I shall suppose that a planet is noticed in the west at 10 P.M., in April, 1896. Plate 41 shows that the situation of the body must have been about Gemini, for this is the westerly part of the track of the Planets. The Planetary Index demonstrates that Jupiter alone occupies this region, for Mars is about Sagittarius; Venus about Pisces; and Saturn about Libra. The object enquired about must therefore be Jupiter.

The following may serve as an illustration of the use of the monthly maps, and of the various indexes to the Planets :—

On a fine evening in January, 1892, at a quarter to five, a bright object, clearly a planet, is low down in the sunset glow. There is another planet higher up to the east, and beyond that again is the Moon, about seven days old. Name the planets.

The planet low down is probably Venus. This is confirmed by the Index to Venus, which refers to Plate 46, for January, 1892, showing that Planet to be in Capricornus or Aquarius. The Index to Jupiter shows it to be in Pisces. The Moon is also seen, from page 23, to lie in Aries, and Plate 47 shows the position of the constellation at the time the observation was made.

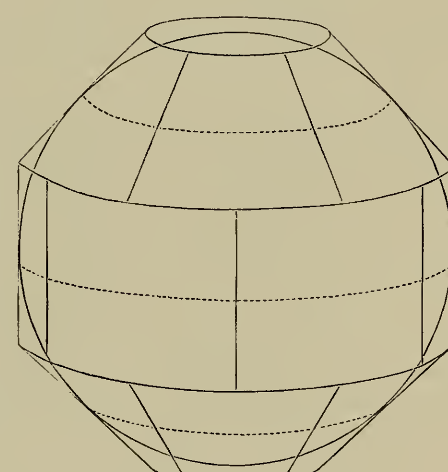
CHAPTER VI.—THE STAR MAPS.

Plates 51 to 70.

The student who has made himself familiar with the appearance and movements of the Constellations, and has acquired a facility in identifying the brighter Stars, will soon feel the need of something further. More especially will this be the case if he has the use of a telescope of even moderate dimensions; and it is to meet these requirements that the Star Maps on Plates 51 to 70 have been prepared.

The first step in drawing a map is to decide on the nature of the projection to be employed. It must be understood that no flat maps can give a perfectly faithful representation of a curved surface, and whatever method of projection is resorted to, the result must represent the surface in a more or less distorted form. The Stars appear to be situated on the surface of a sphere, and however we may attempt to depict them, we cannot include any large portion of the sphere exactly as it appears to the eye. The form of projection which I have used in these maps is that known as the conical projection, and in adopting it I follow Argelander, who employed this method in his great Durchmusterung Atlas, which represents more than 300,000 Stars in the Northern Hemisphere alone.

Imagine two cones touching the sphere around the circle of 45° declination, north and south. These are intersected by tangent planes at the Poles, and by a cylinder touching the sphere around the Equator; *see* adjoining figure. Each star on the sphere is joined to the centre, and the joining line when produced necessarily cuts some one of the enveloping surfaces in a point which is the projection of the star. The equatorial girdle and the two cones are each divided into six equal parts, which admit of being laid out flat; and the eighteen parts thus obtained, together with the two polar planes, make up the twenty maps which represent the entire sphere.



The top and bottom margins of each of these maps, with the exception of the first and last, are divided so as to read Right Ascensions.

Only the hour lines have been drawn on the maps, so as to avoid overcrowding, and for the same reason only the circles corresponding to every tenth degree in Declination have been given. But by the aid of the divisions around the margin, it is easy to read the position of a star, or to enter any desired object with all requisite accuracy. For this purpose it will be found convenient to copy the scale in Declination, which is given on the margin of each map, on the edge of a sheet of paper. If, then, it is desired to enter on the map the position of any object (say a comet) whose R.A. and Declination are known, it is only necessary to set this sheet of paper so that the graduated edge cuts the top and bottom circles at

the R.A. of the object, and to put a dot on the map at the point of the scale corresponding to its Declination. In the same way the position of any object entered on the map may be read off. In the case of maps 51 and 70, the method of reading off positions is somewhat different. In these the declination scale will be found on the radius corresponding to $0^{h.}$, $6^{h.}$, $12^{h.}$ or $24^{h.}$ This scale should be rotated around the centre until it passes through the star whose position is required. The R.A. will then be found at the point of the circumference where the scale cuts it, and the Declination will be read from the scale itself. The epoch for which the places are given is 1880.

It has been arranged that each zone of maps overlaps those north and south of it for a distance of five degrees in Declination, and each map of a zone overlaps those preceding and following it for a space of 40 mins. in R.A.

In order to avoid breaking up conspicuous star groups, I have made the zero, from which the hour circles are measured, pass through the centre of the first map (No. 52) of the intermediate zones, while the same circle divides the first and last maps of the equatorial zone. By this mode of dividing the heavens it has been found possible to comprise each of the more striking configurations of stars within a single map. The only exception is the great square of Pegasus, which will be found on Plates 52, 58, and 63. For convenience in passing from one map to another, the numbers of the plates which represent adjacent portions of the sky have been printed just inside the margin.

In the construction of these maps I have followed, to a great extent, the *Uranométrie Générale* of Houzeau. It contains all the stars visible to the naked eye under the most favourable circumstances, and the number amounts to nearly 6,000.

In the nomenclature of the stars, however, I have departed considerably from Houzeau, doing away in general with letters (other than those of the Greek alphabet), and substituting, wherever possible, Flamsteed's numbers.

I have followed Houzeau throughout in the estimation of star magnitudes, as by so doing I obtained a uniform system over the whole sky, both in the Northern and Southern Hemispheres, determined by a single observer in the same climate and within a short time. His work, besides, is more recent than that of Argelander, Heis, or Behrmann. I have further, for simplicity, limited the number of magnitudes given by Houzeau to six, namely, 1, 2, 3, 4, 5, and 6, which will be found sufficient for all ordinary purposes. These I have indicated on the maps themselves, as shown by the scale at the foot of each map, where, in addition to the size of the dot representing the star, its magnitude is denoted by the number of rays diverging from it. Thus all stars of the first magnitude possess 6 rays, those of the second magnitude 5 rays, and so on. The magnitude of a star may be found by subtracting the number of the rays from seven, except for the sixth magnitude, in which case the single ray has been omitted, stars of this class being represented by a simple dot.

Throughout the maps a large number of the stars will be found accompanied by the letter D. This signifies that the star, though appearing as a single body to the naked eye, is in reality double. This does not however denote duplicity, or a binary character in the usual sense of the word, but merely that the point of light thus characterized will be found to break up into two with the aid of a small telescope. A number of variable stars have been inserted in the maps, as they must always be objects of interest to the student of Astronomy. In the case of those stars which, though variable in brightness, are always bright enough to be seen, I have assumed a magnitude intermediate between their greatest and least brilliancy, and printed *var.* after their designation. The fainter ones are represented by a small circle with a point at the centre. The following is a list of the Variable Stars on these maps, selected from the *Annuaire du Bureau des Longitudes.*

REGULARLY VARIABLE STARS.

Name.	Greatest and Least Mag.	R.A.	Decl.
T Ceti	5·2 — 6·7	0h. 16m.	− 20° 43′
R Andromedæ	7·1 — <12·8	0 18	+ 37 55
R Sculptoris	5·8 — 7·7	1 21	− 33 9
o Ceti	3·3 — 8·8	2 13	− 3 31
ρ Persei	3·4 — 4·2	2 57	+ 38 22
β Persei	2·3 — 3·5	3 0	+ 40 29
λ Tauri	3·4 — 4·2	3 54	+ 12 9
R Leporis	6·5 — 8·5	4 54	− 14 59
U Orionis	6·9 — <12·0	5 49	+ 20 9
η Geminorum	3·2 — 4·0	6 8	+ 22 33
T Monocerotis	6·1 — 7·8	6 19	+ 7 9
S Monocerotis	4·9 — 5·4	6 34	+ 10 0
ζ Geminorum	3·7 — 4·5	6 57	+ 20 45
R Geminorum	7·2 — <13·5	7 0	+ 22 53
L_2 Puppis	3·5 — 6·3	7 10	− 44 26
S Canis Min.	7·6 — <11·0	7 26	+ 8 34
U Geminorum	9·3 — 13·1	7 48	+ 22 19
N Velorum	3·4 — 4·4	9 28	− 56 29
R Carinæ	5·0 — 9·7	9 29	− 62 16
R Leonis	5·9 — 9·7	9 41	+ 11 59
l Carinæ	3·7 — 5·2	9 42	− 61 56
U Hydræ	4·5 — 6·2	10 32	− 12 45
R Hydræ	4·5 — 9·7	13 23	− 22 40
S Virginis	6·7 — 12·5	13 27	− 6 35
δ Libræ	5·0 — 6·2	14 55	− 8 2
S Herculis	6·7 — 12·3	16 46	+ 15 8
3 Sagittarii	4·0 — 6·0	17 40	− 27 47
γ_1 Sagittarii	5·0 — 6·5	17 57	− 29 35
Anon.	5·2 — 7·5	18 41	− 5 50
κ Pavonis	4·0 — 5·5	18 45	− 67 24
β Lyræ	3·4 — 4·5	18 46	+ 33 13
R Aquilæ	6·9 — 11·2	19 1	+ 8 3
χ Cygni	5·2 — 13·5	19 46	+ 32 37
η Aquilæ	3·5 — 4·7	19 47	+ 0 43
Anon.	6·8 — 8·0	20 40	+ 17 40
T Vulpeculæ	5·5 — 6·5	20 47	+ 27 35
δ Cephei	3·7 — 4·9	22 25	+ 57 48
R Cassiopeiæ	5·9 — 10·9	23 52	+ 50 43

IRREGULARLY VARIABLE STARS,

AND STARS WHOSE PERIOD IS NOT KNOWN.

Nova 1572	>1·0 — ?	0 18	+ 63 29
*Nova 1885	7·0 — <12·5	0 37	+ 40 37
ϵ Aurigæ	3·0 — 4·5	4 53	+ 43 39
Nova 1892	4·5 — ?	5 24	+ 30 21
R Velorum	6·5 — 7·5	10 2	− 51 37

* In the great Nebula of Andromeda.

IRREGULARLY VARIABLE STARS—*continued.*

Name.	Greatest and Least Mag.	R.A.	Decl.
S Carinæ	6·2 — 9·0	10h. 6m.	− 60° 58′
η Argûs	>1·0 — 8·0	10 40	− 59 4
Schjellerup 152	5·5 — 6·5	12 40	+ 46 3
Anon.	5·5 — 6·5	13 28	− 12 37
T Centauri	6·1 — 9·3	14 8	− 59 22
R Coronæ	5·8 — 13·0	15 44	+ 28 32
Nova 1866 .... = T Coronæ	2·0 — 9·5	15 55	+ 26 15
Nova 1860 .... = T Scorpii	7·0 — <12·0	16 10	− 22 41
Nova 1848	5·5 — 12·5	16 53	− 12 43
α Herculis...	3·1 — 3·9	17 9	+ 14 31
Nova 1604	>1·0 — ?	17 23	− 21 23
Nova 1670	3·0 — ?	19 43	+ 27 1
Nova 1876	3·2 — 13·5	21 37	+ 42 18
μ Cephei	4·0 — 5·0	21 40	+ 58 14
19 Piscium	4·8 — 6·2	23 40	+ 2 50

The places in the above lists are given for the epoch 1880, as it was considered that the advantage of having it identical in this respect with the epoch chosen for the charts, would counterbalance any advantage to be gained by choosing a later date; there is also a convenience in having the star places for the same epoch as Webb has selected in his excellent work, *Celestial Objects for Common Telescopes.*

In many of the maps will be found an asterisk, closely accompanied by a date. This marks the radiant point of a meteor shower, and the date accompanying it is that on which the shower takes place. The following is a list of such radiant points, which is based on a similar list by Mr. W. F. Denning, in *The Admiralty Manual of Scientific Enquiry,* 1886.

Table of Dates and Radiant Points of the Principal Meteor Showers.

No.	Date of Shower.	Radiant Point. R.A. Time. h.	m.	Arc. °	Decl. °	
1	January 1-3	15	28	232	+ 49	
2	January 5-11	9	40	145	+ 5	Marked by the star 4 Sextantis.
3	January 28	15	44	236	+ 25	
4	February 5-10	4	56	74	+ 43	
5	February 15	15	44	236	+ 11	
6	February 16	11	8	167	+ 5	
7	February 20	12	4	181	+ 34	
8	March 4	11	44	176	+ 9	
9	April 9-12	16	36	249	+ 51	
10	April 18-20	17	56	269	+ 33	
11	April 30	21	44	326	− 2	
12	May 11	15	24	231	+ 27	
13	May 30	22	0	330	+ 28	Marked by the star 23 Pegasi.
14	June 13	20	40	310	+ 61	Marked by the star η Cephei.
15	June 25-30	16	52	253	+ 47	
16	July 23-25	3	12	48	+ 43	Midway between 30 and 32 Persei.

Table of Dates and Radiant Points—*continued.*

No.	Date of Shower.	Radiant Point. R.A. Time. h.	m.	Arc. °	Decl. °	
17	July 28	22	44	341	− 13	
18	August 9-11	3	0	45	+ 57	
19	August 21-25	19	24	291	+ 60	
20	September 7	4	8	62	+ 37	
21	September 21	2	4	31	+ 19	Marked by the star 15 Arietis.
22	September 25	6	36	99	+ 43	
23	October 15	7	4	106	+ 23	
24	October 18	6	0	90	+ 15	
25	November 1	2	52	43	+ 22	
26	November 12-14	9	56	149	+ 23	
27	November 13-18	10	20	155	+ 40	
28	November 19-23	4	8	62	+ 21	Marked by the star 51 Tauri.
29	November 27	1	40	25	+ 43	
30	Nov. 30—Dec. 4	12	56	194	+ 43	
31	December 1-10	7	48	117	+ 32	
32	December 6	5	20	80	+ 23	
33	December 10-12	7	12	108	+ 33	

Plates 71 and 72.

As I have already pointed out, the region of the sky which corresponds to any one of the general series of maps, is indicated by the dotted lines in the series of monthly maps (Plates 39 to 50). This, however, is chiefly useful at localities about the latitude of the British Islands. For the convenience of those living in other latitudes, to whom it is hoped this Atlas will recommend itself, as well as to enable the student at home to choose the maps suitable for his purpose with greater rapidity, I have added the Northern and Southern Index Maps (Plates 71 and 72). In these the principal constellations are marked, and the outlines of each map of the general series, with the numbers of the corresponding plates in bold figures. Each Index Map includes from the Pole to 25° beyond the Equator, so that both contain the series of Equatorial maps. Around the circumferences is marked each hour of R.A. The Declination is not indicated, but it can be ascertained with sufficient accuracy for the purpose of finding the required map by remembering that the Equatorial zone extends to 25° Declination, and the intermediate zones to 70° Declination, while each zone overlaps that above and below it by 5°.

PRECESSION.

The Precession of the Equinoxes, or the slow motion of the Earth's axis, in consequence of which the intersection of the Equator with the Ecliptic travels along the latter, brings about a constant change in the R.A. and Declination of the Stars from year to year. It is thus clear that the values of these quantities as read from the maps will only be strictly accurate at the epoch for which the maps are drawn. In order to find the R.A. and Declination for any other date, it is necessary to apply a correction for this precessional effect, and if it is desired to mark upon the maps the position of any star or other object whose co-ordinates are given for a date different from that of the Atlas, a similar correction must be applied.

It must, however, be borne in mind that no change takes place from this cause in the

relative position of the stars,—the effect being merely to give the whole system of Right Ascension and Declination circles a shift, and thus to alter the positions of all the stars with regard to them.

For accurate astronomical work, the correction for precession must in general be computed to a small fraction of a second, and elaborate tables have been prepared to facilitate this operation; but for all purposes coming within the scope of the present work, the following tables will be found amply sufficient.

That given on this page contains the correction to the R.A. for 10 years' precession. The quantity found in the table is to be added, with the sign there indicated to the R.A. at any time, in order to obtain the R.A. for an epoch 10 years later, or it is to be subtracted to find the R.A. at an epoch 10 years earlier. For intervals other than 10 years a proportional allowance must be made. The top and bottom lines contain the Declination, and the first and last columns the R.A.

For most purposes it will be sufficient in finding the precession to take the R.A. to the nearest whole hour, and the Declination to the nearest multiple of 10 degrees. If the star is situated in the Northern Hemisphere, we find its Declination in the first or last line, and run the eye down the corresponding column till we reach the line which contains the star's R.A. in the first column; the corresponding figure in the table is the precession in R.A. for 10 years. If the star is in the Southern Hemisphere, we look for its Declination as before, but we find its R.A. in the last column.

The second table, containing the correction to the Declination for 10 years, is still more simple. We have merely to enter it with the nearest hour of R.A. in the extreme columns, and we find in the central column the corresponding correction to the Declination. For all R.A.'s found on the left side the correction is positive, and negative for all those on the right side.

The signs of the precessions given in both tables show the correction necessary to bring the star's place up to a subsequent date; to bring it back to an earlier date the signs must be altered. The table of precession in R.A. extends to 70° north and south of the Equator, so that it is applicable to all the stars except those around the North and South Poles, contained in Plates 51 and 70.

TABLE FOR PRECESSION IN R.A.

R.A. for N. Decl.	0°	10°	20°	30°	40°	50°	60°	70°	R.A. for S. Decl.
h. h.	m.	m.	m.	m.	m.	m.	m.	m.	h. h.
18 or 18	+0·51	+0·47	+0·43	+0·38	+0·33	+0·25	+0·13	−0·10	6 or 6
19 „ 17	·51	·47	·43	·39	·33	·26	·14	·08	5 „ 7
20 „ 16	·51	·48	·44	·40	·35	·28	·18	−0·02	4 „ 8
21 „ 15	·51	·48	·45	·42	·38	·32	·24	+0·08	3 „ 9
22 „ 14	·51	·49	·47	·45	·42	·38	·32	·21	2 „ 10
23 „ 13	·51	·50	·49	·48	·46	·44	·41	·35	1 „ 11
0 „ 12	·51	·51	·51	·51	·51	·51	·51	·51	0 „ 12
1 „ 11	·51	·52	·53	·54	·56	·58	·61	·67	23 „ 13
2 „ 10	·51	·53	·55	·58	·61	·64	·70	·82	22 „ 14
3 „ 9	·51	·54	·57	·60	·64	·70	·78	0·94	21 „ 15
4 „ 8	·51	·55	·58	·62	·67	·74	·85	1·04	20 „ 16
5 „ 7	·51	·55	·59	·64	·69	·77	·88	1·10	19 „ 17
6 „ 6	+0·51	+0·55	+0·59	+0·64	+0·70	+0·78	+0·90	+1·12	18 „ 18
R.A. for N. Decl.	0°	10°	20°	30°	40°	50°	60°	70°	R.A. for S. Decl.

Table for Precession in Declination.

R.A.			Precession.	R.A.		
h.		h.	°	h.		h.
0	or	24	+ 0·06 −	12	or	12
1	„	23	·05	13	„	11
2	„	22	·05	14	„	10
3	„	21	·04	15	„	9
4	„	20	·03	16	„	8
5	„	19	·01	17	„	7
6	„	18	·00	18	„	6

Example.—The star Capella is situated in 1880 in R.A. 5 h. 8 m., Declination + 45°·9 : find what its R.A. and Declination will be in 1905.

Entering the first Table with R.A. 5 h., and Declination 50°, we find 10 years' precession in R.A. is + 0·77 m. Hence the corresponding correction for 25 years will be to the nearest whole minute + 2 m.

Entering the second Table with R.A. 5 h., we find 10 years' precession in Declination is + 0°·01, hence to the tenth of a degree the correction for 25 years is negligible, so that we find in 1905 R.A. = 5 h. 8 m. + 2 m. = 5 h. 10 m., and Declination = + 45°·9.

If it were required to find the place of the star at the beginning of the century (*i.e.*, 80 years previously), we have to multiply + 0·77 m. and + 0°·01 by − 8, and we find the corrections — 6 m. and — 0°·1, so that the place of this star in 1800 is R.A. 5 h. 2 m., Declination + 45°·8.

As another example, let us find the R.A. and Declination of ω Draconis in 1940. Its place in 1880 is 17 h. 38 m. ; + 68°·8. We find from the Tables — 0·10 m. as correction for 10 years' precession, and 0°·00 as the correction in Declination ; we thus obtain for 1940 R.A. = 17 h. 38 m. − 0·6 m. = 17 h. 37 m. to the nearest minute, and Declination + 68°·8.

Once more, suppose that in 1950 it is announced that a comet has been seen in R.A. 3 h. 42·9 m., and Declination + 23°·96. We find the precession in R.A. and Declination from the tables to be, for 10 years, + 0·58 m. and + 0°·03. Hence, to bring the place back to 1880, we have the correction — 4·1 m. and — 0°·21. We thus have

	Comet's R.A.			Comet's Declination.
	h.	m.		°
1950............................	3	42·9	...	+ 23·96
Correction for Precession...		− 4·1	...	— 0·21
1880............................	3	38·8	...	+ 23·75

That is to say, the place occupied by the comet is indicated on these maps by the figures just found for 1880, so that it would be found at the time of the announcement in the centre of the group of the Pleiades.

CHAPTER VII.—SELECT TELESCOPIC OBJECTS.

In preparing a list of objects suitable for observation with small instruments, the following works among others have been consulted :—*Smyth's Celestial Cycle*, *Webb's Celestial Objects*, *Darby's Astronomical Observer*, *Crossley, Gledhill, and Wilson's Double Stars, and The Companion to the Observatory.* Below the name of each object is given its position, and then a reference to the plate or plates on which it may be found. Nebulæ and clusters are occasionally referred to Sir J. Herschel's General Catalogue, *e.g.*, H 1067.

SELECT TELESCOPIC OBJECTS.

34 Piscium.
0h. 4m. + 10° 29′
58, 63.

A fine, double star, when viewed in a good telescope, 4° south and 3m. preceding γ Pegasi. The principal star is of the 6th mag., and the companion is of the 11th. The position-angle is 160°, and the distance 7″·8. The colours of the stars are silvery white and pale blue.

35 Piscium.
0h. 9m. + 8° 9′
58, 63.

This pair is an easier object than the last. The stars are 6th mag., white, and an 8th mag. of a purplish tint. Like the preceding, the components appear to be relatively fixed. Position-angle 150°, and distance 11″·9.

38 Piscium.
0h. 11m. + 8° 12′
58, 63.

This beautiful pair follows the last at an interval of 2m., almost in the same parallel. It was believed by Herschel I. to be in motion, but later measures seem to establish its fixity: the position-angle is 240°, and the distance 4″·5. The components are respectively, 7½m. yellow, and 8m. white.

42 Piscium.
0h. 16m. +12° 49′
58, 63.

This wide double is a beautiful object in the telescope, on account of the strongly contrasted tints of the components, which have been described as topaz and emerald. The position-angle and distance as determined by Gledhill, in 1873, were 338°·1, and 29″·0, respectively. Although the stars appear to be slowly approaching each other, this movement is probably not of an orbital character, but is due to the proper motion of the principal star

The Great Nebula in Andromeda.
0h. 36m. +40° 35′
52.

Figured in Plate 14. See page 16. This object is the only nebula visible to the unaided eye. It is, both from its size and brightness, one of the two most famous nebulæ (the other being the great nebula in Orion). This object is certainly not a mere star cluster. At the same time, the spectroscopic evidence of its gaseous character is not so convincing as in some other bright nebulæ. To study a nebula, it is well to point the telescope so that the object is just out of the field, and then allow it to enter by the diurnal motion.

η Cassiopeiæ. 0h. 42m. + 57° 11′ 52.

The duplicity of this interesting object was discovered in 1779, by Sir Wm. Herschel. It has thus been under observation for more than 100 years. In this period its binary character has been clearly established. According to Doberck, its period is 222½ years, and the semi-major axis of its orbit is 9″·8. In 1856, Otto Struve found its parallax to be 0″·15, so that its light takes 22 years to reach us. This star is also affected with a considerable proper motion, amounting to 1″·2 annually. The colours of the components are yellow and purple, and their magnitudes 4 and 7½ respectively. (Gledhill, 147°·2 ; 5″·8, 1876).

36 Andromedæ. 0h. 49m. + 23° 0′ 52, 58.

This beautiful double star can be detected by the naked eye between η and ζ of the same constellation. Although tolerably close, it is not a difficult object to measure, on account of the approach to equality in the magnitude of the components. They are 6th and 7th magnitudes respectively, of an orange tint. It seems to be of a binary character, though of long period. An orbit computed by Doberck, in 1875, which gives a period of 349 years, and semi-major axis 1″·54, represents the motion fairly well. (Dembowski, 356°·2 ; 1″·3, 1877).

φ Piscium. 1h. 7m. + 23° 57′ 52, 58.

The components of this star are of the 6th and 13th magnitudes respectively, the position-angle is 226°·5, and the distance 9″. It seems probable that the companion is variable.

α Ursæ Min. (Polaris) 1h. 15m. + 88° 40′ 51.

This is in some respects the best known and most practically important star in the sky. On account of its proximity to the North Pole, it appears to the naked eye to be almost devoid of the ordinary diurnal movement in which the others stars partake. In early days, before the invention of the magnetic compass, the navigator used to steer his ship by the indications of the Pole-star. In the modern Observatory it still maintains a position of importance as a mark for the adjustment of instruments, although the motion which it shares in common with all the other stars, but in a smaller degree than most, can no longer be overlooked. It is situated at such an enormous distance from the Sun, that its parallax is almost insensible, and its light must take *at least* 63 years in reaching us.

The principal star, which is of the 2nd magnitude, is attended by a small companion, about 9½ in magnitude, situated at a distance of 19″, and position-angle 212°. So far there does not appear to be any evidence of a change in the relative position of the components. The Pole-star can easily be found in the sky by the aid of α and β Ursæ Majoris, "the pointers," as they have been called. An imaginary line drawn through these two, and continued about five times the distance separating them, will pass near the Pole-star, which, once found, will be easily remembered by its apparent fixity in the sky.

γ Arietis. 1h. 47m. + 18° 42′ 58.

This star is interesting as having been discovered as a double star by Hooke as early as 1664, when he was observing the Comet of that year : "a like instance to which I have not else met with in all the heavens." Its components are of the 4th magnitude, and of a white and bluish colour respectively. The distance is 8″·3, and position about 359°. There is a slight change in the distance, but whether orbital or parallactic, is not yet clear.

α Piscium.
1h. 56m. + 2° 11′
58.

A beautiful double star, of which the components are of the 5th and 6th magnitudes respectively. The colours have been variously stated, but are generally designated green and bluish. The position-angle appears to be slowly diminishing, being now (1892) 325°, and the distance 3″·5.

γ Andromedæ.
1h. 57m. + 41° 45′
52, 53.

This object, which is the second in a conspicuous line of four stars leading from α Persei to α Andromedæ, is one of the finest objects of its class in the heavens. In most telescopes it appears as a double, composed of two stars, yellow 3·5, and sea-green 5·5, respectively. The latter is situated at 62°, 10″, and appears stationary with regard to the primary. In 1842, Otto Struve discovered that the companion was itself double, its two components being nearly of the same magnitude. Both position-angle and distance appear to be diminishing slowly, being at present 104° and 0″·3.

ι Trianguli.
2h. 5m. + 29° 44′
52, 53.

An exquisite double star, of which the primary is yellow and of the 5th magnitude, and the companion blue and 7th magnitude. The position-angle is at present about 74°, and the distance 3″·5. It may possibly be binary, but the motion is very slow.

The Clusters in Perseus.
2h. 11m. + 56° 36′
52, 53.

This splendid pair of clusters, viewed on a clear night, when the Moon is absent, form the most striking sidereal spectacle in the Northern heavens. They can easily be found as a condensation of brightness in the Milky Way, on the line joining α Persei with δ Cassiopeiæ, at about three-fifths of the distance from the former. The preceding cluster is the richer of the two, and contains hundreds of stars from the 7th magnitude down to the extreme limits of visibility, grouped in the "enchanting disorder of Nature" within a space of about half a degree square. Near the centre is a beautiful horse-shoe or coronet of 6 stars, graduated in brightness from the 8th to the 10th or 11th magnitude, and in other parts of the mass several minor groups of somewhat similar form may be detected.

The other cluster follows on the same parallel at 3 minutes interval. It covers a somewhat smaller space, and does not present such a wealth of stars as the preceding object. The principal features of this group are two conspicuous triangles of 9th, 10th, and 11th magnitude stars on its preceding side.

Nebula H 527
Andromeda.
2h. 15m. + 41° 47′
52, 53.

An elongated nebula, which presents the appearance of a flat ring seen almost edgewise. Discovered by Miss Herschel in 1783, using only a Newtonian of 27 inches focal length, and power of 30. Possibly variable, for sometimes very difficult to see.

P II. 72
Cassiopeiæ.
2h. 19m. + 66° 52′
51, 52, 53.

A remarkable triple star. The primary is a 4th magnitude star, of a yellowish colour, attended at a distance of 8″, and position-angle 108°, by an 8th magnitude star of a fine blue tint, which, so far, appears to have remained stationary with regard to the primary. In 1779, Sir Wm. Herschel discovered that the primary was itself a close double. This nearer *comes* is situated at a distance of 2″, and position-angle 265°, and is probably in slow orbital motion. All three are affected by a common proper motion.

ν Ceti.
2h. 30m. + 5° 3′
53.

A double star, of which the components are of the 5th and 10th magnitudes, and the colours pale yellow and blue respectively. The distance is 7″·5, and the position-angle 83°. The companion is a difficult object to most observers, though Webb found it "easy with 5½-inch in 1861."

A double star of the 6th and 10th magnitudes respectively. The companion, which is situated at a distance of 4″·6, and position-angle 316°, partakes of the considerable proper motion of the primary, and is probably in slow orbital motion around it. A difficult object. 84 Ceti. 2h. 35m. − 1° 13′ 58.

A triple Star—A of the 4th, B of the 10th, and C of the 9th, magnitudes. A and B are affected with the same proper motion, amounting to nearly 1″ annually, and probably form a binary system. The distance is 16″·5, and the position-angle 296° at present. C is situated at a distance of 68″, and position-angle 216°, and is almost certainly not in physical connection with the other two. The colours are yellow, violet, and grey. θ Persei. 2h. 36m. + 48° 43′ 53.

A beautiful double star. Components—3·5 pale yellow, and 7 blue, with common proper motion. Probably a very slow binary. The position-angle is 290°, and distance 2″·7. γ Ceti. 2h. 37m. + 2° 44′ 58.

A coarse quadruple star, of which the components are—A, 3rd magnitude, white; B, 13th magnitude, blue; C, 11th magnitude, orange; D, 9th magnitude, grey. Burnham gives the following positions for 1879 :— 41 Arietis. 2h. 43m. + 26° 46′ 53.

	Position Angle.	Distance.
	°	″
A and B	266·0	21·2
A and C	203·5	34·0
A and D	230·2	125·9

And adds, "There seems to be considerable change in C, and perhaps some in B."

This is one of the most wonderful stars in the heavens. From early times it was known as an extraordinary variable, and obtained in consequence its name, Algol, or "the Demon Star." For 2 d. 12 h. this star remains of the 2nd magnitude. Within 4½ hours it falls to the 4th magnitude, and remains so for 18 m., after which it begins to recover its brightness, and within another 4½ hours it has regained the 2nd magnitude. These changes are repeated with regularity in a period of 2 d. 20 h. 48 m. 55 s. β Persei (Algol 3h. 0m. + 40° 30′ 53.

Up to the year 1888, the cause of this variability was unknown. Prof. Vogel's recent spectroscopic researches have shown that the changes in Algol's brightness are caused by the passage of a darker satellite, which revolves around the primary in the same period as that in which the variations take place. Algol is therefore a double star, belonging to a novel class, which contains a few other somewhat similar objects. The distance between the components is about 3,000,000 miles.

This 1st mag. star, conspicuous for its ruddy colour, is the principal object in the group of the Hyades, which is shown in Map 59, 42 m. following, and 8° south of the Pleiades. It has a faint companion of the 12th mag., at 35° position-angle, and 115″ distance. Burnham discovered a very minute attendant of the 14th mag. at 111°, 31″, which is a severe test for all but the largest telescopes. α Tauri (Aldebaran) 4h. 29m. + 16° 16′ 59.

Aldebaran is affected by a considerable proper motion, amounting to nearly ⅕th of a second annually. An occultation of Aldebaran by the moon, which not unfrequently occurs, is a striking phenomenon.

7 Camelopardalis.
4h. 48m. + 53° 33′
53.

A triple star, long known as a double, composed of a 4th mag. white star, accompanied at position-angle 239°, distance 27″, by an 11th mag. orange-coloured attendant. In 1864 Dembowski discovered a close 8th mag. olive-coloured companion, at a distance of 1″·2, and position-angle 309°.

β Orionis (Rigel)
5h. 9m. − 8° 20′
59.

A very difficult object in any but the best telescopes, notwithstanding the large distance of 9″·5. The brilliance of the principal star, which is of the 1st mag., overpowers the feeble luminosity of the attendant of the 8th mag., situated at position-angle 200°. Burnham found the companion double with the Chicago 18½-inch refractor.

Cluster H 1067
Auriga.
5h. 12m. + 39° 13′
53.

Sir Wm. Herschel describes this as "a pretty compressed cluster, with one large star, the rest nearly of a size." The principal star is of the 8th mag., and of a bright orange colour.

Cluster H 1119
Auriga.
5h. 21m. + 35° 47′
53.

A fine cluster, described by Admiral Smyth as "an oblique cross, with a pair of large stars in each arm, and a conspicuous one in the centre, the whole followed by a bright individual of the 7th mag." There are several wide doubles scattered through it, and the whole region is very beautiful.

32 Orionis.
5h. 24m. + 5° 51′
59.

A difficult double of the 5th and 7th magnitudes, both white. Position-angle and distance are both diminishing, and were, in 1887, 189° and 0″·44 respectively. Probably binary.

δ Orionis.
5h. 26m. − 0° 23′
59.

A wide double star, the preceding of the three gems in Orion's belt. The primary is a brilliant white star of the 2nd mag., and the companion a pale violet of the 7th mag. The position-angle is 359°, and the distance 53″. Burnham added another faint 14th mag. attendant at pos. 227°, distance 34″.

Nebula H 1157
Taurus.
5h. 27m. + 21° 56′
53, 59.

This object was first seen by Bevis in 1731, but accidentally discovered again by Messier when observing the comet of 1758; a circumstance which led to the formation of his famous Catalogue of 103 Clusters of Stars and Nebulæ, which was the first of its kind. This is the "Crab Nebula" of the Earl of Rosse, whose great 6-foot reflector succeeded in resolving it into a cluster of stars.

Great Nebula in Orion.
5h. 29m. − 5° 28′
59.

Figured in Plate 14. See p. 16. This, the famous nebula in Orion, and the nebula in Andromeda, are by far the grandest objects of their class visible to observers in the Northern Hemisphere. Even in a small telescope many of the features of the Orion nebula are to be discerned, and in a great instrument the object is not surpassed in interest by any other telescopic spectacle. The bluish hue of the great nebula seems connected with the fact that the spectroscope reveals the presence of Hydrogen. Multitudes of stars are scattered over the field, and framed in the densest part of the nebula lies the superb multiple star, θ Orionis.

39 λ Orionis.
5h. 29m. + 9° 51′
59.

A beautiful double star, situated in a splendid region. The components are 4th mag. pale yellow, and 6th mag. purplish, respectively. This star, with ϕ_1 and ϕ_2 Orionis, form a triangle to the naked eye, which constitutes the head of Orion.

A beautiful multiple star. In most ordinary telescopes it presents the appearance described by Sir Wm. Herschel as "a double-treble star, or two sets of treble stars almost similarly situated." In larger instruments both sets are seen to be quadruple. With the great Dorpat refractor, Struve found the group to consist of 15 stars. σ Orionis. 5h. 33m. – 2° 40′ 59.

This, the following of the three stars in Orion's belt, is composed of three—A, 2nd mag., yellow; B, $6\frac{1}{2}$ mag., purplish; and C, 10th mag., grey. B is situated at position-angle 157°, distance 2″·4, and appears to be in motion relative to A. C is situated at position-angle 8°, and distance 60″, and in its case no relative motion has been detected. ζ Orionis. 5h. 35m. – 2° 0′ 59.

A glorious cluster, supposed by Messier to be partly nebulous, but resolvable with moderate means into about 500 stars from the 10th to the 14th magnitudes. "Even in smaller instruments extremely beautiful, one of the finest of its class. Gaze at it well and long."—*Webb*. Cluster H 1295 Auriga. 5h.44m. + 32° 32′ 53, 54.

This brilliant object can scarcely be put in the category of double stars on account of the distance (161″) of the companion, discovered by Sir Wm. Herschel at position-angle 152°. It is conspicuous for its ruddy orange colour, which contrasts very strikingly with the cold blue tint of β (Rigel) when compared with the naked eye. It is irregularly variable in brilliance, but is at all times a striking object in the telescope. Huggins and Miller find its spectrum to be of a remarkable type. α Orionis Betelgeux. 5h. 49m. + 7° 23′ 59.

A very striking triple star, composed of A, 5 mag.; B, $5\frac{1}{2}$ mag.; C, 6 mag.; all white. B is situated at 131° and 7″ distance; C at 124°, 9″·5. There is also a fourth star of the 12th mag. at 56°, 26″. 11 Monocerotis. 6h. 23m. – 6° 57′ 59.

This magnificent object has attracted attention from the earliest times as being the brightest star in the heavens. It was hence regarded as being our nearest neighbour, but modern research has proved that it is far more remote than many telescopic stars. Gill and Elkin fixed its parallax at 0″·39. From certain irregularities in its motion, Bessel suggested in 1844 that it was in orbital motion around a darker companion—an idea which was strikingly confirmed by Alvan Clark's discovery in 1862 of a faint companion, in position-angle 84°·5, and distance 10″·1. It is now an extremely difficult object. Remarkable investigations on the spectrum of Sirius and other stars of an allied character reveal the presence of Hydrogen. The orbit of this double has been investigated by several computers. The latest of these—Mr. Gore's—gives a period of 58·47 years, eccentricity 0·4055, and semi-axis-major 8″·58. α Canis Majoris (Sirius). 6h.40m. – 16° 33′ 59.

A pretty double star, of which the primary is of the 4th magnitude, white, and the companion 11th magnitude, yellowish. Suspected of variability. λ Geminorum. 7h. 11m. + 16°45 59.

A rather difficult double star, of which the components are $3\frac{1}{2}$ magnitude, white, and 9th magnitude, purple, respectively. The companion is situated at 194°, 7″ at present. The position-angle is slowly increasing. δ Geminorum. 7h. 13m. + 22° 12′ 54, 59.

α Geminorum (Castor)
7h. 27m. + 32° 9′
54.

This, which Sir John Herschel calls the largest and finest of all the double stars in our hemisphere, is an excellent object for small telescopes. It was the first star shown to be certainly of a binary character; the first orbit being computed by Sir John Herschel, who attributed to it a period of 253 years. Subsequent observations have increased this nearly four-fold, the latest researches pointing to a majestic period of about 1000 years. The components are almost equal in brightness, their magnitudes being 3 and 3½ respectively. The position-angle is at present about 230°, and the distance 5″·5.

κ Geminorum.
7h. 37m. + 24° 41′
54, 59.

A very beautiful double star; components 4th magnitude, orange, and 10th magnitude, blue, respectively. Position-angle 231°·9, distance 6″.

11 Cancri.
8h. 1m. + 27° 50′
54.

A double star; the components 7th magnitude, pale yellow, and 12th magnitude, lilac. Position-angle 219°, distance 3″.

ζ Cancri.
8h. 5m. + 18° 1′
59, 60.

One of the most remarkable *multiple* stars in the heavens. It is composed in the first place of two stars, A and B, of the 5 and 5·7 magnitude respectively, whose orbit has been well determined. These two revolve around each other, in a period of 60 years, at a distance of less than 1″, and are accompanied by a third star, C, of 5·5 magnitude, which revolves around the centre of gravity of all in an opposite direction. From irregularities in the motion of C, which take place in a period of 17½ years, it is concluded that it is but a satellite of an invisible body around which it revolves in that time, describing an ellipse with a radius of about one-fifth of a second, and that the two together circle around A and B in 600 or 700 years.

Præsepe.
8h. 33m. + 20° 22′
54, 60.

A fine cluster of stars, which can be detected by the naked eye as a nebulous patch of light a little to the south, preceding γ Cancri. A fine object in small telescopes.

ε Hydræ.
8h. 40m. + 6° 51′
60.

A beautiful double star, of which the components are—3·8 magnitude, yellow, and 7·8 magnitude, blue, respectively. The position-angle is increasing, and is at present about 229°; the distance 3″·3. It is attended at 192°, 20″ by a 13th magnitude companion.

Cluster H 1712
Cancer.
8h. 45m. + 12° 15′
60.

In this cluster Sir Wm. Herschel saw above 200 stars at once in the field of view from the 10th to 15th magnitude.

ω Leonis.
9h. 22m. + 9° 36′
60.

This very close and difficult double star has been under observation for nearly a whole revolution, but owing to the difficulty of making the measures, its orbit is not so certain as would otherwise be the case. It was discovered to be double by Sir Wm. Herschel, in 1783, and the latest investigation of its orbit—that by Doberck—gives its period as 110·82 years. The components are of the 6th and 7th magnitudes respectively, but as the distance is never more than about 1″, it requires a powerful telescope.

R. Leonis.
9h. 41m. + 11° 59′
60.

This is a remarkable variable star which ranges from 5·9 to 9·7 in magnitude. In all stages of brilliance it is specially to be noticed on account of its fiery red colour. Its spectrum, when near its maximum brightness, is characterised by bright hydrogen lines.

Two fine nebulæ, separated by half a degree. The preceding is a bright oval nebula of a white colour, with a central condensation, and several small stars in the neighbourhood. The other is a long narrow object, somewhat paler. Huggins finds the spectra of both nebulæ similar to that of the great nebula in Andromeda. Nebulæ H 1949, 1950, Ursa Major. 9h. 46m. + 69° 41′ 51, 54.

A very fine double star, composed of a 2nd magnitude, orange, and a 4th magnitude, reddish green. The orbit has been computed by Hind and Doberck. The latter estimates its period at 407 years, and its mean distance at 2″. There is a 7th magnitude star at position-angle 293°, and distance 229″. γ Leonis. 10h. 13m. + 20° 27′ 54, 60.

This may be taken as a type of these strange objects, great globes of gas, remarkably contrasted with nebulæ of the more ordinary types by the definite nature of the margin which surrounds them. Planetary Nebula H 2102, Hydra. 10h. 19m. − 18° 2′ 60.

A neat double star in a fine field. The primary is of the 7th magnitude, yellow, and the companion of the 8th magnitude, blue. The position-angle is 240°, and distance 6″·8. 35 Sextantis. 10h. 37m. + 5° 23′ 60.

A pale yellow star of the 3rd magnitude, accompanied by a 13th magnitude of a blue tint. It is interesting as being one of the stars observed by Flamsteed, in 1690, with the planet Uranus, which he then took for a fixed star. δ Leonis. 11h. 8m. + 21° 11′ 55, 60.

This object appeared to Messier merely as a formless spot of faint light. In ordinary telescopes it presents the appearance of a faintly illuminated disc about the size of Jupiter. In the most powerful telescopes it is found to be of a complicated structure. The Earl of Rosse found two condensations surrounded by spirals in opposite directions, from which it obtained the name of the "Owl Nebula." This nebula gives a spectrum of bright lines, from which its gaseous character may be inferred. Planetary Nebula H 2343, Ursa Major. 11h. 8m. + 55° 40′ 55.

This beautiful double star is in some respects the most interesting of its class. On account of the approach to equality in the brightness of the components (7·3 and 8·2), the measures are not very difficult, though the distance is small, amounting to about 3″ at most. The orbit of this system has been frequently computed. The period is 60·79 years, according to Dunér. ξ Ursæ Majoris. 11h. 12m + 32° 12′ 55.

A double star, composed of a 4th magnitude, pale yellow, and a $7\frac{1}{2}$ magnitude, light blue. Supposed by Smyth and Dawes to be a binary system, but this is doubtful. Position-angle is 70°, and distance 2″·8. ι Leonis. 11h. 18m. + 11° 12′ 60.

A close double star, of which the components are—A, 4th magnitude, white, and B, 10th (?) magnitude, grey. The position-angle and distance of B are 98° and 5″ respectively. γ Crateris. 11h. 19m. − 17° 1′ 60.

An interesting double star, A, 7th magnitude, white; B, $9\frac{1}{2}$ magnitude, purplish. Position-angle 36°, distance 3″·8; attended at position-angle 113°, and distance 63″, by a third star, C, 7th magnitude, white. 65 Ursæ Maj. 11h. 49m. + 47° 9′ 55.

A remarkable nebula, with three spiral branches springing from a central condensation. Spiral Nebula H 2838, Virgo. 12h. 13m. + 15° 4′ 60, 61.

24 Comæ Berenicis. 12h. 29m. + 19° 2′ 61.

A splendid double star, of which the components are—5·5 magnitude, orange, and 7th magnitude, lilac. Position-angle 271°, distance 20″. The colours form a "striking and beautiful contrast."—*Webb.*

γ Virginis. 12h. 36m. − 0° 47′ 61.

A most interesting binary system, consisting of two stars of the 4th magnitude. A study of its movements led Sir John Herschel to predict, in 1832, that within the next year or two its distance (which in 1831 was 1″·5) would close up to such an extent, "that none but the very finest telescopes will have any chance of showing this magnificent phenomenon." This prediction was verified in 1836, when the Dorpat refractor alone was able to elongate the star, all others seeing it as a single point. Many orbits have been computed for this pair, the best giving a period of 185 years. It is at present not a difficult object to divide, the distance being about 5″.

Cor Caroli. 12h. 50m. + 38° 58′ 55.

A very easy and interesting double. It forms, with the three stars of the Great Bear's tail, a quadrilateral that could be circumscribed by a circle. Magnitudes 2·5, 6·5. Position 225°, distance 19″·8.

Nebula H 3321 Coma Berenicis 12h. 51m. + 22° 20′ 55, 61.

This is a fine nebula, but, like most of these objects, requires a large telescope to make it *effective.*

Nebula H 3453 Coma Berenicis. 13h. 7m. + 18° 47′ 61.

An instructive object, as typical of a certain class of clusters of minute stars. It is not *effective* in any instrument under four inches aperture.

ζ Ursæ Majoris. 13h. 19m. + 55° 33′ 55.

Probably the best known double star in the heavens, and certainly one of the easiest to find and most *effective* to look at in a small telescope. It is the middle star of the Bear's tail, and the adjacent Alcor is doubtless connected with the pair. Magnitudes 3, 5. Position 147°·4, and distance 14″·4. The larger star of the pair has been demonstrated by the spectroscope to be itself a close double, the mass of the two being forty times the mass of the Sun. Thus, counting Alcor, we have a marvellous group of 4 associated Suns.

Nebula H 3572 Can. Ven. 13h. 25m. + 47° 49′ 55.

Lord Rosse's great telescope at Parsonstown gave the first indication of the spiral nature of this object, which has been completely established by the wonderful photographs that Mr. Isaac Roberts has obtained. In a small instrument this particular feature will not be seen, but an interesting pair of nebulæ is the appearance presented.

Nebula H 3636 Can. Ven. 13h. 37m. + 28° 58′ 55.

A globular cluster of stars when seen in a large telescope, and a nebulous spot when seen in a small one.

α Bootis. 14h. 10m. + 19° 49′ 61.

Arcturus. Easily recognised by prolonging the sweep of the Bear's tail. This is one of the gems of the sky, a first magnitude star, with a lustre about equal to that of Vega or Capella, and a slightly reddish hue as contrasted with the two stars just named.

Cluster H 3900 Virgo. 14h. 23m. − 5° 26′ 61.

Seems like a nebula in a small telescope, and resolved into a cluster by a large one.

This object demands a powerful telescope. It is a close double, each of the components being of the 4th magnitude, the position-angle being 293°·4, and the distance 0″·51.

ζ Bootis.
14h. 35m. +14° 15′
61.

One of the most beautiful of coloured doubles, the components being yellowish and blue. The magnitudes are 3, 7, the position-angle 321°, and the distance 2″·9.

ε Bootis.
14h. 40m. +27° 35′
56.

A double star. Magnitudes 5, 7, position-angle 253°·9, and distance 3″·52 (1888, Maw).

ξ Bootis.
14h. 46m. +19° 36′
61.

An easy pair. This is a binary star. Doberck estimates the period of revolution at 261 years. The magnitudes are 5, 6, and the distance and position-angle in 1877 were 5″ and 238°, respectively.

44 Bootis.
15h. 0m. + 48° 7′
56.

A cluster of minute stars, to the number of 200 in a powerful instrument.

Cluster H 4083 in Libra.
15h. 12m. + 2° 32′
61.

Magnitudes 3, 5; and, according to Hall, the position-angle is 190°, and the distance 3″·5. A fine object.

δ Serpentis.
15h. 29m. +10° 56′
61.

A pair of stars of nearly equal magnitude (6, 6½). The position-angle was 207°, and the distance 3″·78, according to Schiaparelli in 1887.

σ Coronæ.
16h. 10m. +34° 10′
56.

This is a splendid first magnitude star, of a red colour. It has a green companion of the 7th magnitude. Dawes, in 1864, gives its distance and position as 3″·7 and 275°·7, respectively.

α Scorpii.
16h. 22m. −26° 10′
68.

A fine binary star, with a period, according to Doberck, of 234 years. The magnitudes are 4½, 5½; and the smaller star is greenish or bluish. According to Leavenworth (1888) the position is 42°·6, and distance 1″·55.

λ Ophiuchi.
16h. 25m. +2° 15′
62.

A notable binary star. Dunér makes the period 35 years. The magnitudes are 3, 6½; and in 1888, Schiaparelli makes the position-angle 79°·4, and the distance 1″·55.

ζ Herculis.
16h. 37m. +31° 49′
56.

The renowned globular cluster in Hercules. This is the most important object of its class, and is indeed one of the chief beauties of the starry heavens. It consists of thousands of stars, so close together, that in the central parts the rays commingle so that the separate stars cannot be made out.

Cluster H 4230 Hercules.
16h. 37m. + 36° 41
56.

A bright cluster of stars, but a powerful telescope is required to do it justice.

Cluster H 4256 Ophiuchus.
16h. 51m. −3° 56′
62.

A fine pair of 4th and 4·5th magnitudes. According to Dembowski, in 1877, the position-angle was 169°·9, and the distance 2″·5.

μ Draconis.
17h. 3m. +54° 38′
56.

This is one of the very finest coloured pairs. The magnitudes are 3·5, 5·5; the large star being orange, and the small one blue; apparently stationary. The position and distance given by Webb are 118°·7 and 4″·5, respectively.

α Herculis.
17h. 9m. + 14° 32′
62.

ρ Herculis.
17h. 20m. + 37°15′
56.

Struve gives magnitudes as 4, 5·1. The smaller star is a pale blue; and Webb gives position-angle 308°·9, and distance 3″·7.

Nebula H 4373
Draco.
17h. 59m. + 66° 38′
51, 56, 57.

One of the best examples of those extraordinary objects, the Planetary Nebulæ. Huggins finds it to be composed of gaseous materials.

Nebula H 4403
Sagittarius.
18h. 14m. − 16°15′
62.

This is one of the nebulæ that can be observed with comparatively small optical power. The nebula is known as the "Horse Shoe." Huggins has shown it to be gaseous.

Cluster H 4406
Sagittarius.
18h. 17m. − 24°56′
62, 69.

Cluster visible in a moderate instrument, but not a remarkable object.

α Lyræ.
18h. 33m. + 38°40′
57.

Vega, a white, first magnitude star, shown by Huggins to have a vast atmosphere of hydrogen. There is a companion at 46″; position-angle 151°·9 (Knott).

ε Lyræ.
18h. 40m. + 39° 33′
57.

One of the most interesting stellar objects. It is a double star with components about 3′ apart, resolvable with the naked eye. A telescope of 3 inches aperture will show that each of the stars is itself a double, about 2″ or 3″ distance. The whole four are doubtless physically connected.

Nebula H 4447
Lyra.
18h. 49m. + 32°53′
57.

The marvellous ring nebula in Lyra. It is easy to find, and no great optical power is required to show the structure of this most interesting object.

17 Lyræ.
19h. 3m. + 32° 19′
57.

A good illustration of a coloured pair with very unequal components. The magnitudes are 6, 11, the larger being yellow, and the smaller blue.

β Cygni.
19h. 26m. + 27°42′
57.

One of the most beautiful stellar objects, fortunately within the reach of very moderate instruments, both by reason of the brightness of the components, and the distance at which they are separated. The larger star, 3rd magnitude, is topaz coloured, and the smaller 7th magnitude, a beautiful blue. The position-angle and distance are 55°·6; 34″·4 (Webb).

δ Cygni.
19h. 41m. + 44°50′
57.

Magnitudes 3·5 and 9, the smaller star is greenish, but the object is rather difficult for small instruments. Dembowski (1877) gives position-angle 330°·1, and distance 1″·6.

η Aquilæ.
19h. 43m. + 11°31′
62.

A good test object for a small telescope. The stars are 6, 6·8 magnitudes (Struve), and the distance 1″·5.

ε Draconis.
19h. 49m. + 69°58′
51, 57.

A fine pair. Magnitudes 4, 7·6. Position-angle 361°·4; distance 2″·9; (Hall), 1877. The smaller star is a fine blue.

Nebula H 4532
Vulpecula.
19h. 54m. + 22°23′
57, 62.

The famous Dumb-Bell Nebula. This is one of the finest objects of its class. There are many stars in the field, but Huggins shows the nebula itself to be gaseous.

γ Delphini.
20h. 41m. + 15°42′
63.

An easy double star. Magnitudes, 4, 5; 11″·8 apart. Position-angle 273°·3. The colours are different, the larger being yellowish, and the smaller with a bluish tinge.

A notable object, especially as being the first star of which the distance was determined. The magnitudes are 5·3, 5·9, and the position-angle and distance, as determined by Schiaparelli, are 121°·0, 20″·58 (1888). 61 Cygni. 21h. 1m. +38° 10′ 57.

This is a very close and difficult object, interesting as being one of the most rapidly revolving binaries. Magnitudes 4½, 5 ; distance 0″·25. δ Equulei. 21h. 9m. + 9° 31′ 63.

A fine cluster of stars belonging to the globular type, of which that in Hercules is the best known example. Cluster H 4670 Pegasus. 21h. 24m. +11°38′ 63.

A round nebula, which with sufficient power seems to be composed of minute stars. Nebula H 4678 Aquarius. 21h. 27m. – 1° 22′ 63.

A triple star, the largest of which, 5th magnitude, is white, and the others, of the 6th and 7·5th magnitudes, are blue. μ Cygni. 21h. 39m. + 28°12′ 57.

This is the Garnet Sidus of Herschel, which seems the reddest star visible to the naked eye in the heavens. μ Cephei. 21h. 40m. + 58°14′ 57.

A coloured double. Magnitudes 4·7, 6·5 ; position-angle 284°·8, distance 6″·6, (Gledhill, 1874). Dunér records the colours as pale green and purple, 1879. ξ Cephei. 22h. 0m. + 64° 3′ 52, 57.

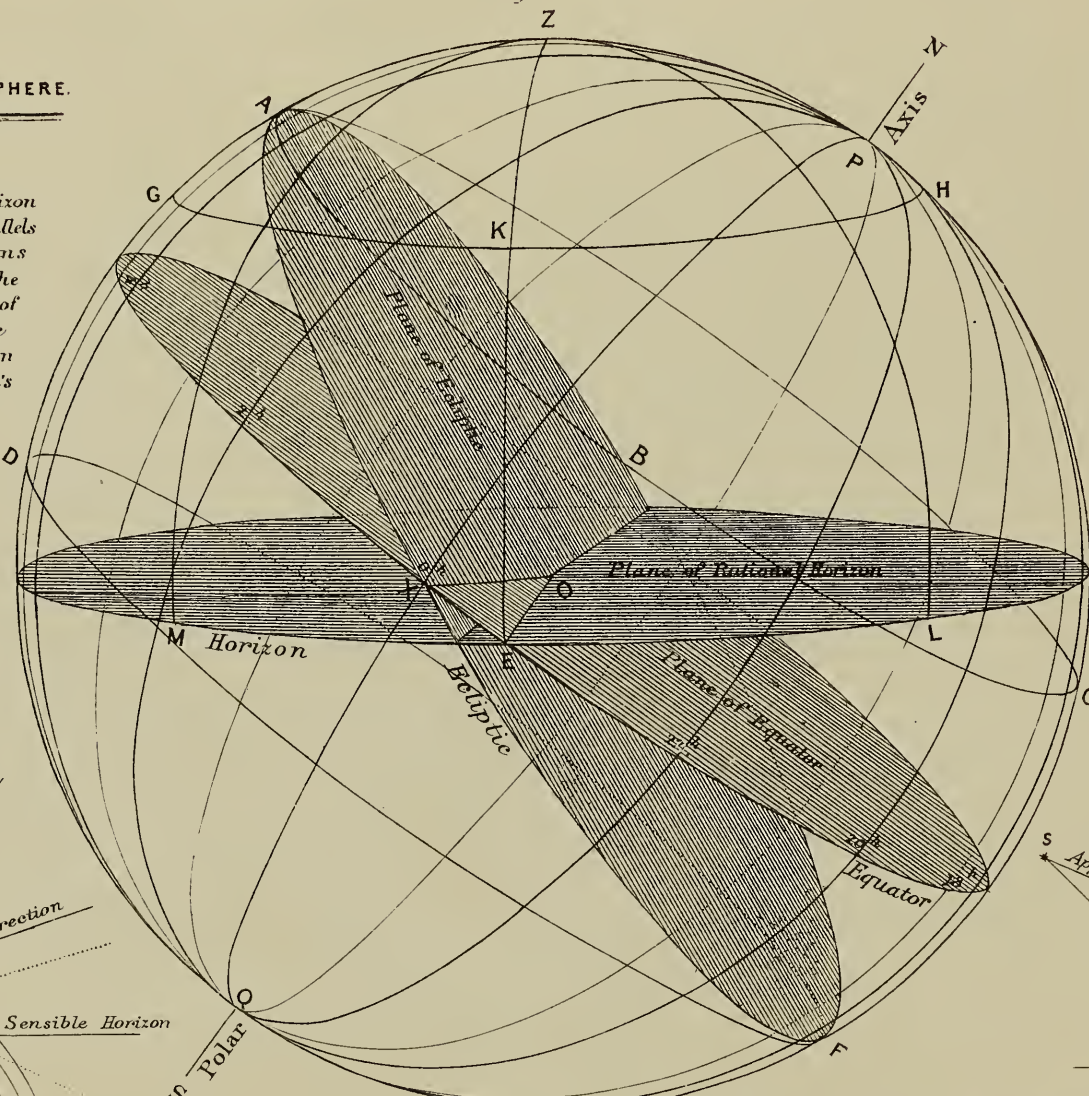
A well-known and striking double star. Easy to find in the centre of a triangle of naked eye stars. The magnitudes are 4, 4 ; position 325°·8 ; Distance 3″·08 (1889), Leavenworth. ζ Aquarii. 22h. 23m. – 0° 38′ 63.

A fine double star. 5·4 and 7·5 magnitudes ; large star white, smaller blue. The position and distance are 323°·7, 3″ (Webb). σ Cassiopeiæ. 23h. 53m. + 55° 5′ 52.

END OF INTRODUCTION.

 THE CIRCLES OF THE SPHERE, REFRACTION AND PARALLAX.

Fig.1



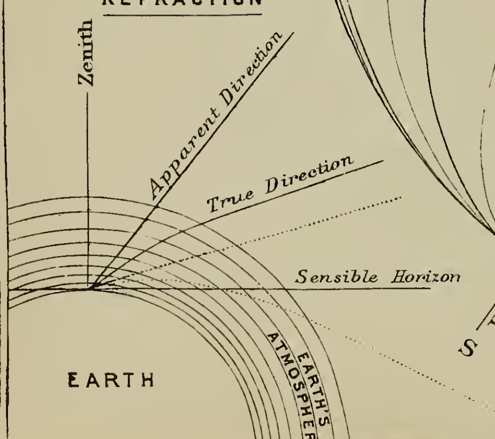
THE CIRCLES OF THE SPHERE.

To the observer the horizon with its system of parallels & vertical circles remains apparently fixed, while the other circles & the Plane of Ecliptic appear to rotate around the Polar Axis in consequence of the Earth's diurnal motion.

In this diagram (fig.1) the Earth is represented by the point O *at the centre of the Sphere.*
E *is the east point of the Horizon,*
Z *is the Zenith,*
P & Q *are the North & South Poles of the Equator respectively.*
The Circle **P X Q** *is the Zero hour circle or equinoctial colure,*
X *is the Equinox or "First Point of Aries".*
The two parallels to Equator **A B C & D E F** *are the Tropics of Cancer and Capricorn respectively & represent the Sun's diurnal path at Midsummer & Midwinter.*
Z L & Z M *are two Vertical Circles.*
Z K E *is the "Prime Vertical."*
G K H *is the circle of 45° altitude.*

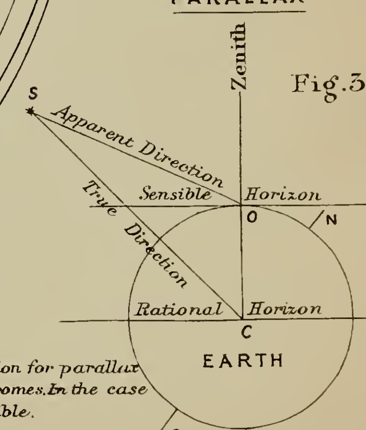
Fig.2

REFRACTION



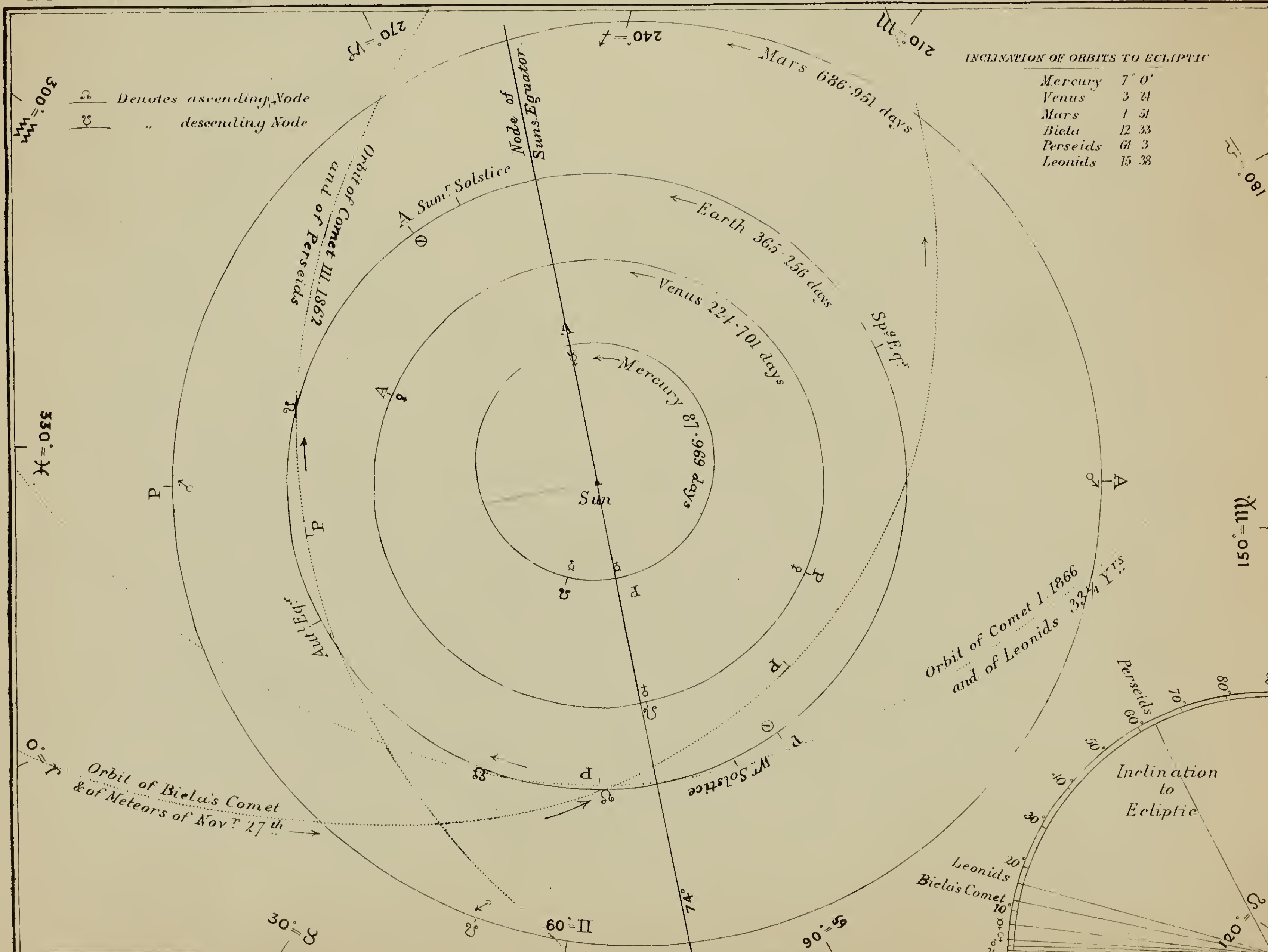
PARALLAX

Fig.3



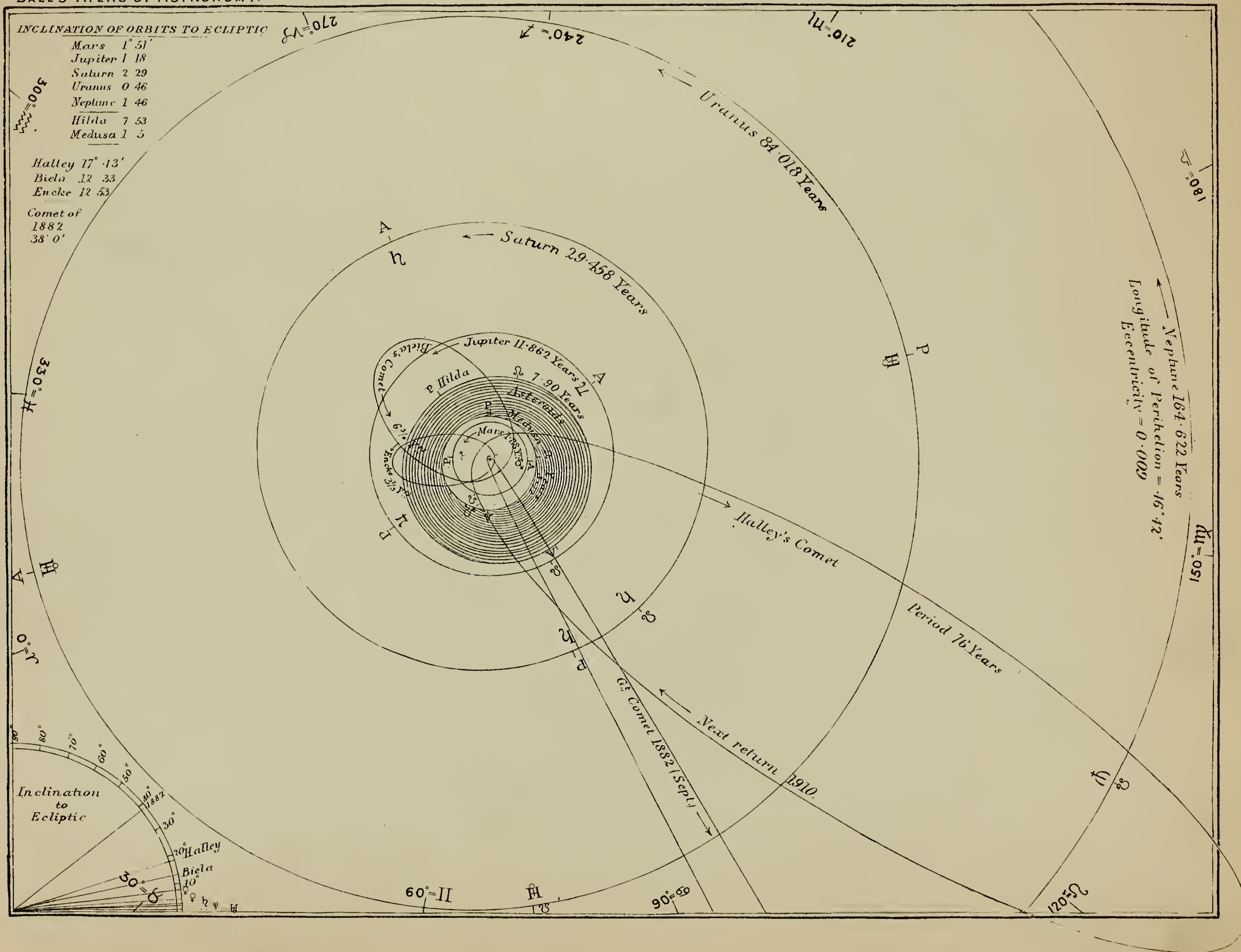
The angle O S C *(fig 3) is the correction for parallax. The further S is the smaller this angle becomes. In the case of the fixed stars this angle is insensible.*

THE INNER PLANETS.

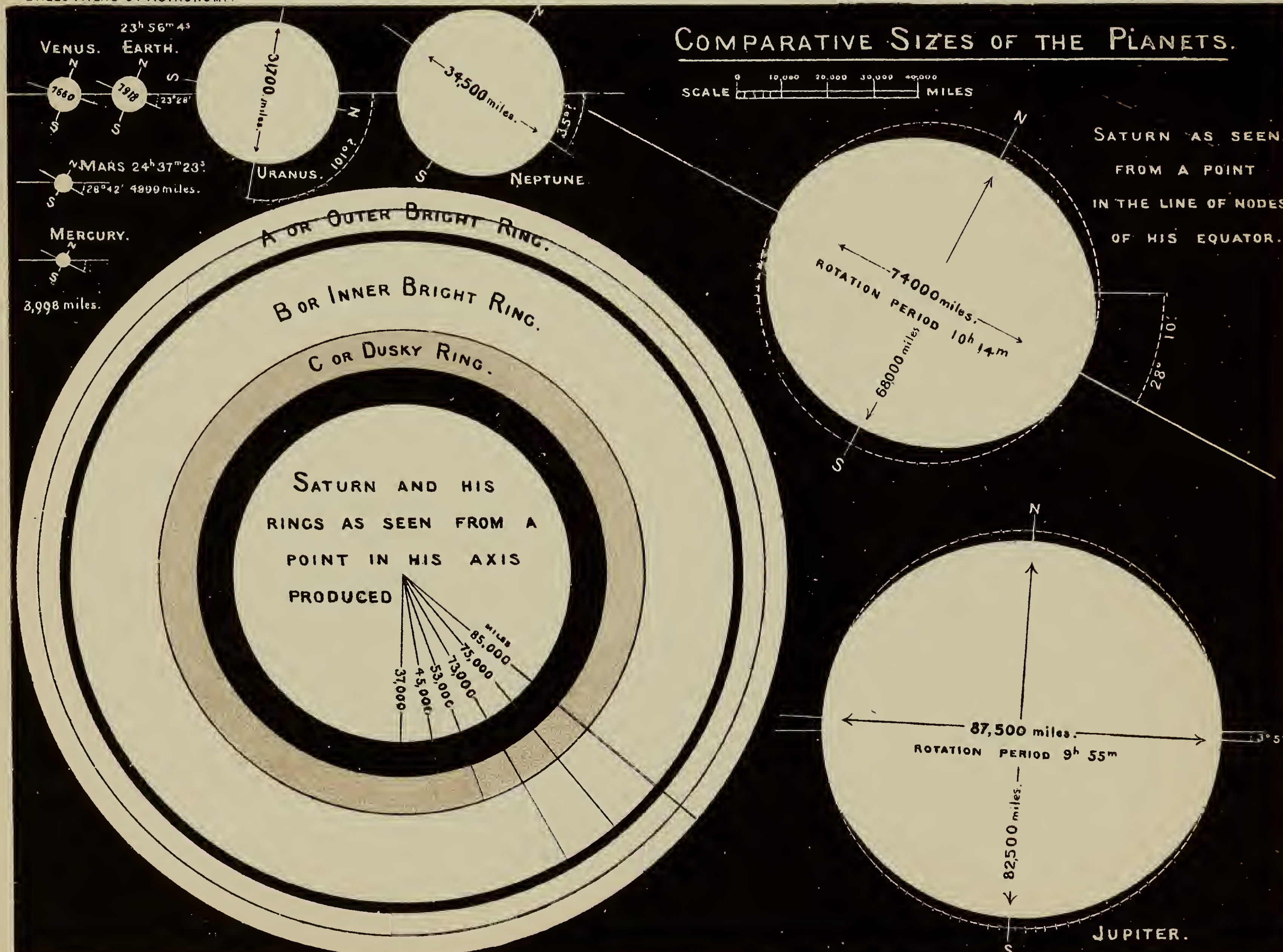


THE OUTER PLANETS

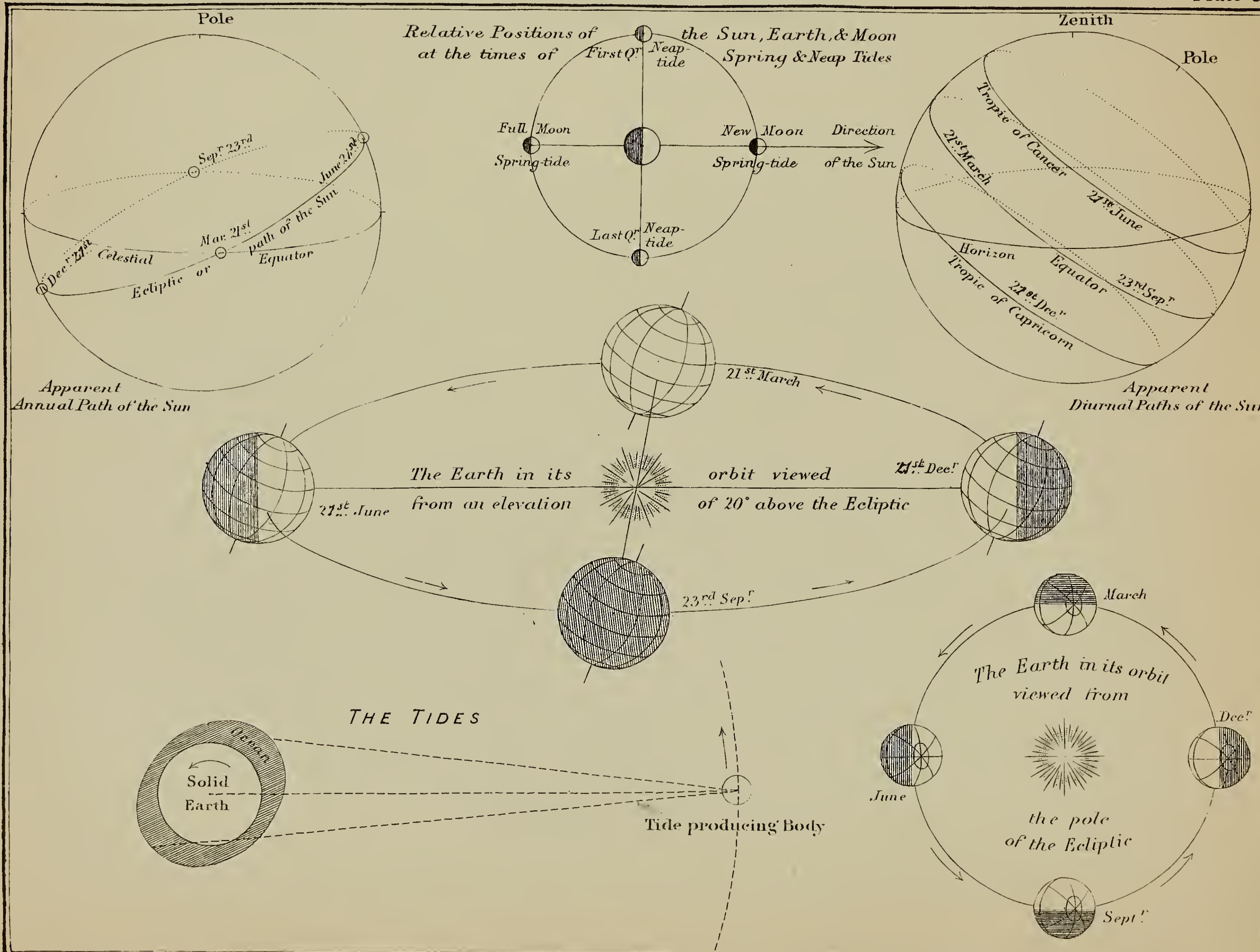
Plate 3



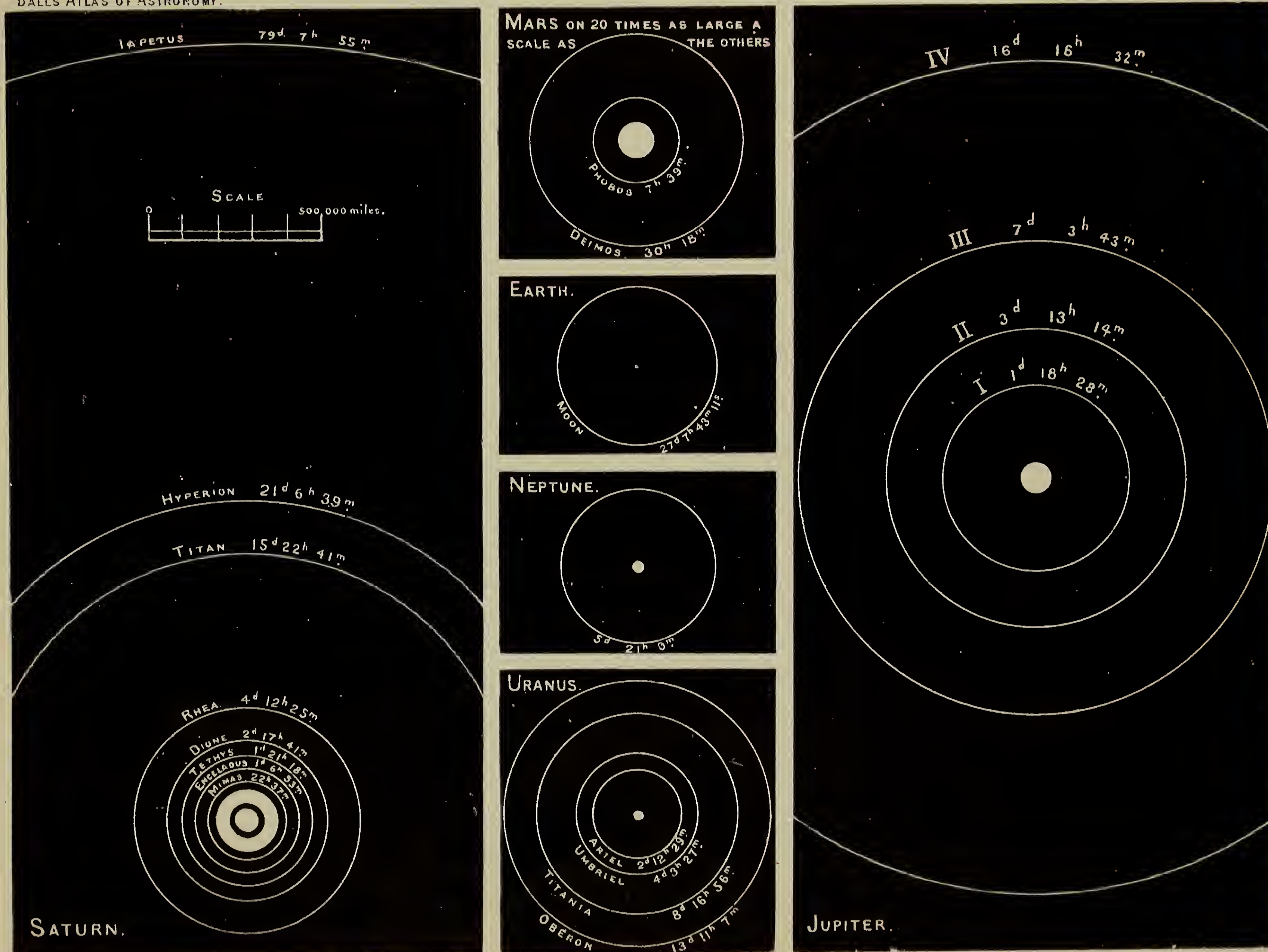
Ball's Atlas of Astronomy. THE PLANETARY SYSTEM. Plate 4.



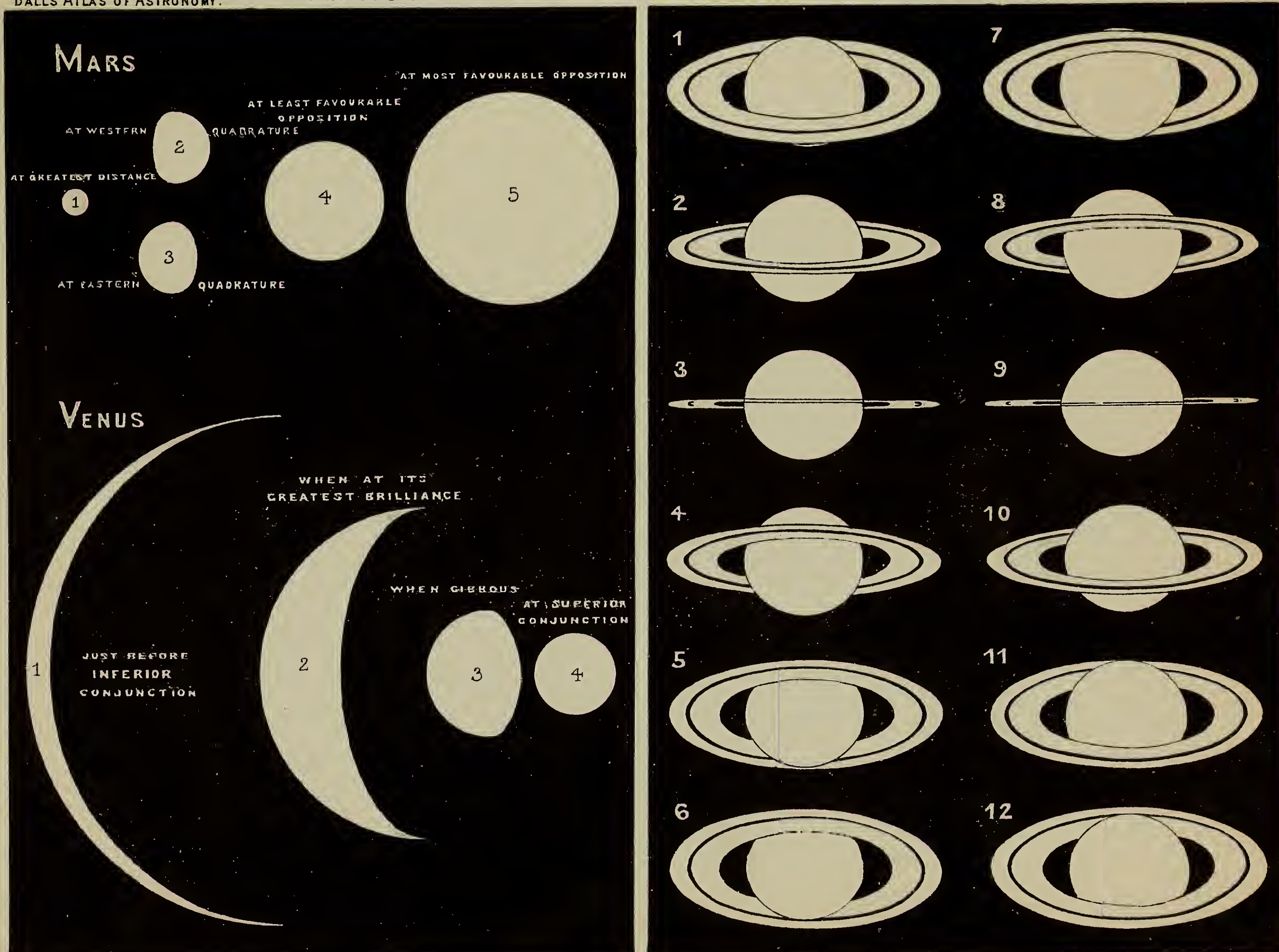
THE SEASONS AND THE TIDES.



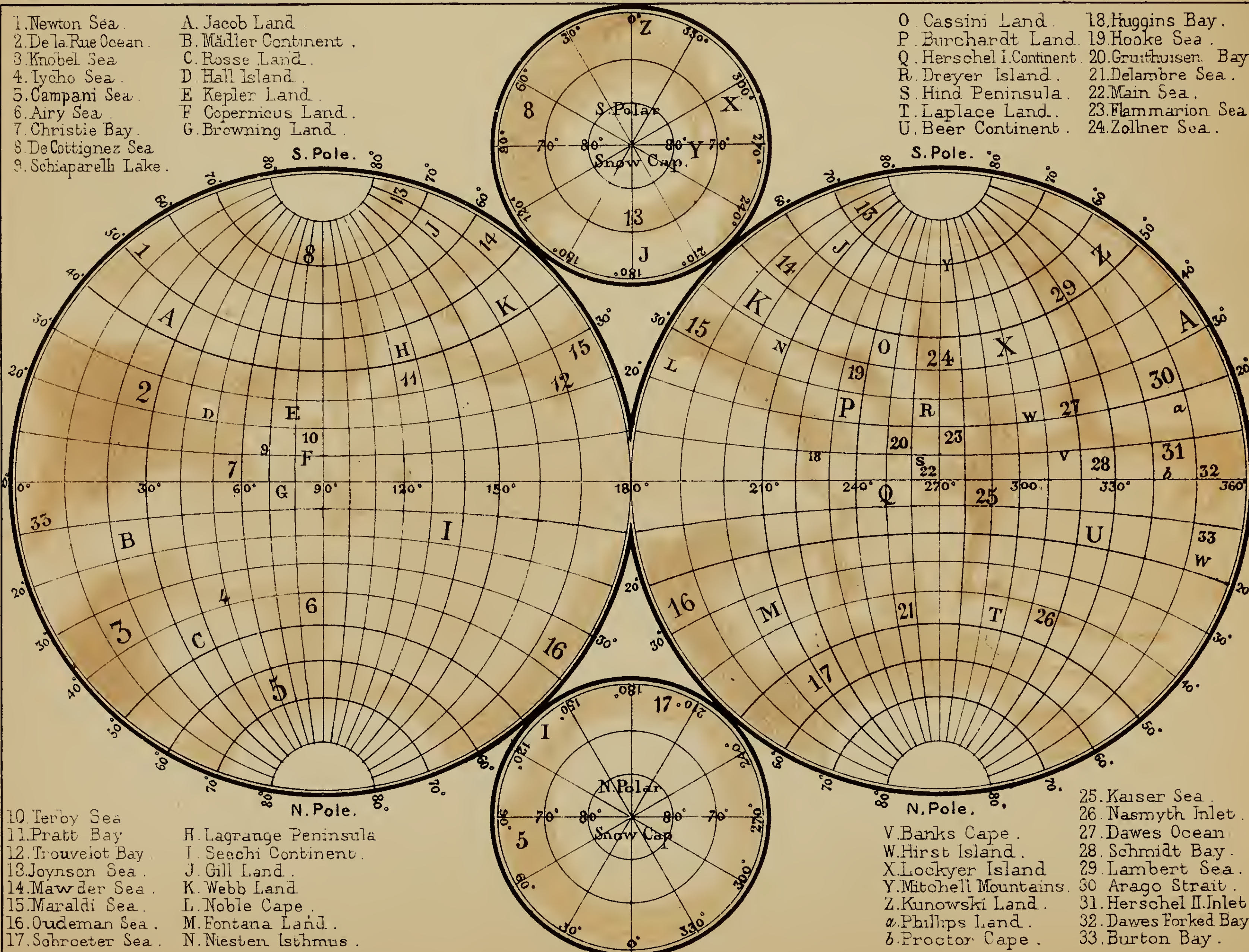
SYSTEMS OF SATELLITES.



PHASES OF THE PLANETS & OF THE RINGS OF SATURN.



A CHART OF MARS.



1. Newton Sea.
2. De la Rue Ocean.
3. Knobel Sea.
4. Tycho Sea.
5. Campani Sea.
6. Airy Sea.
7. Christie Bay.
8. De Cottignez Sea.
9. Schiaparelli Lake.

A. Jacob Land.
B. Mädler Continent.
C. Rosse Land.
D. Hall Island.
E. Kepler Land.
F. Copernicus Land.
G. Browning Land.

O. Cassini Land.
P. Burchardt Land.
Q. Herschel I. Continent.
R. Dreyer Island.
S. Hind Peninsula.
T. Laplace Land.
U. Beer Continent.

18. Huggins Bay.
19. Hooke Sea.
20. Gruithuisen Bay.
21. Delambre Sea.
22. Main Sea.
23. Flammarion Sea.
24. Zollner Sea.

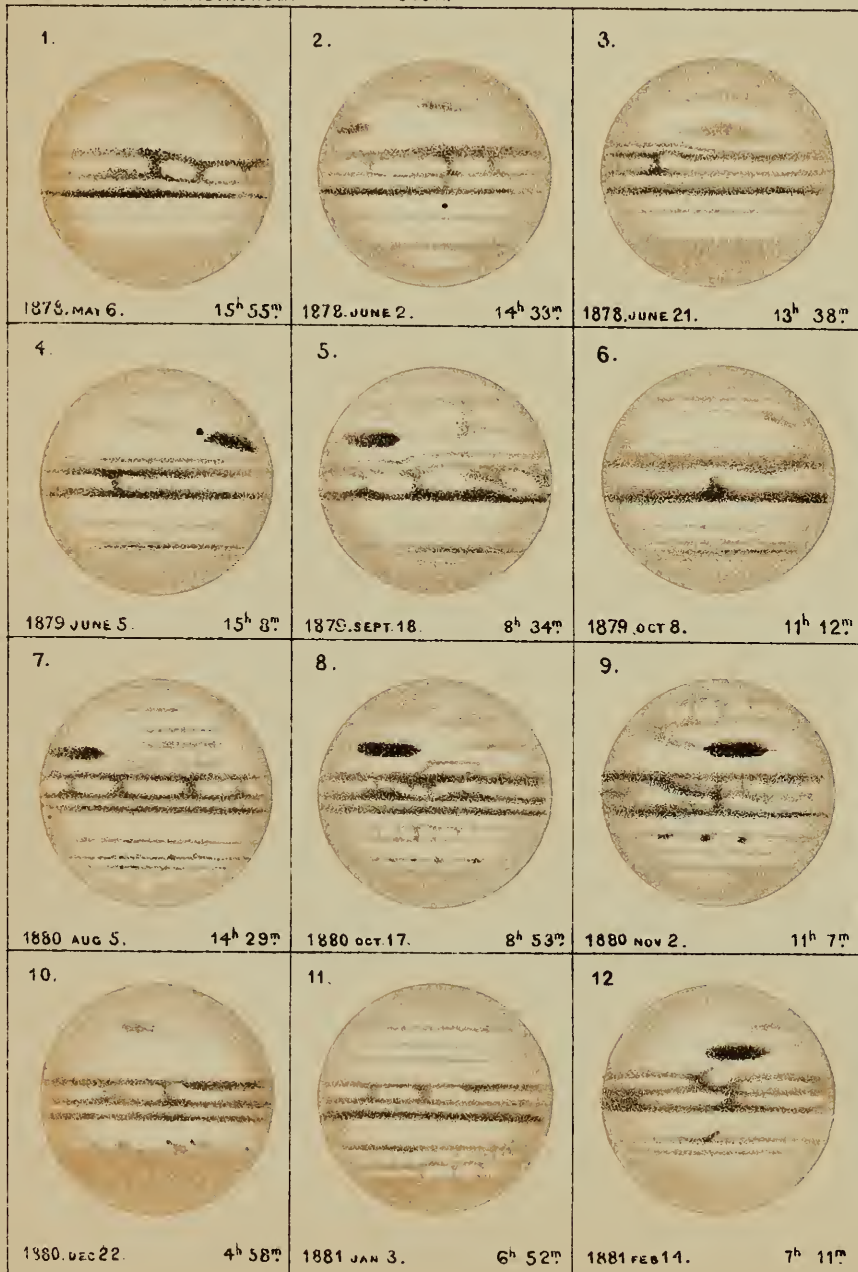
10. Terby Sea.
11. Pratt Bay.
12. Trouvelot Bay.
13. Joynson Sea.
14. Mawder Sea.
15. Maraldi Sea.
16. Oudeman Sea.
17. Schroeter Sea.

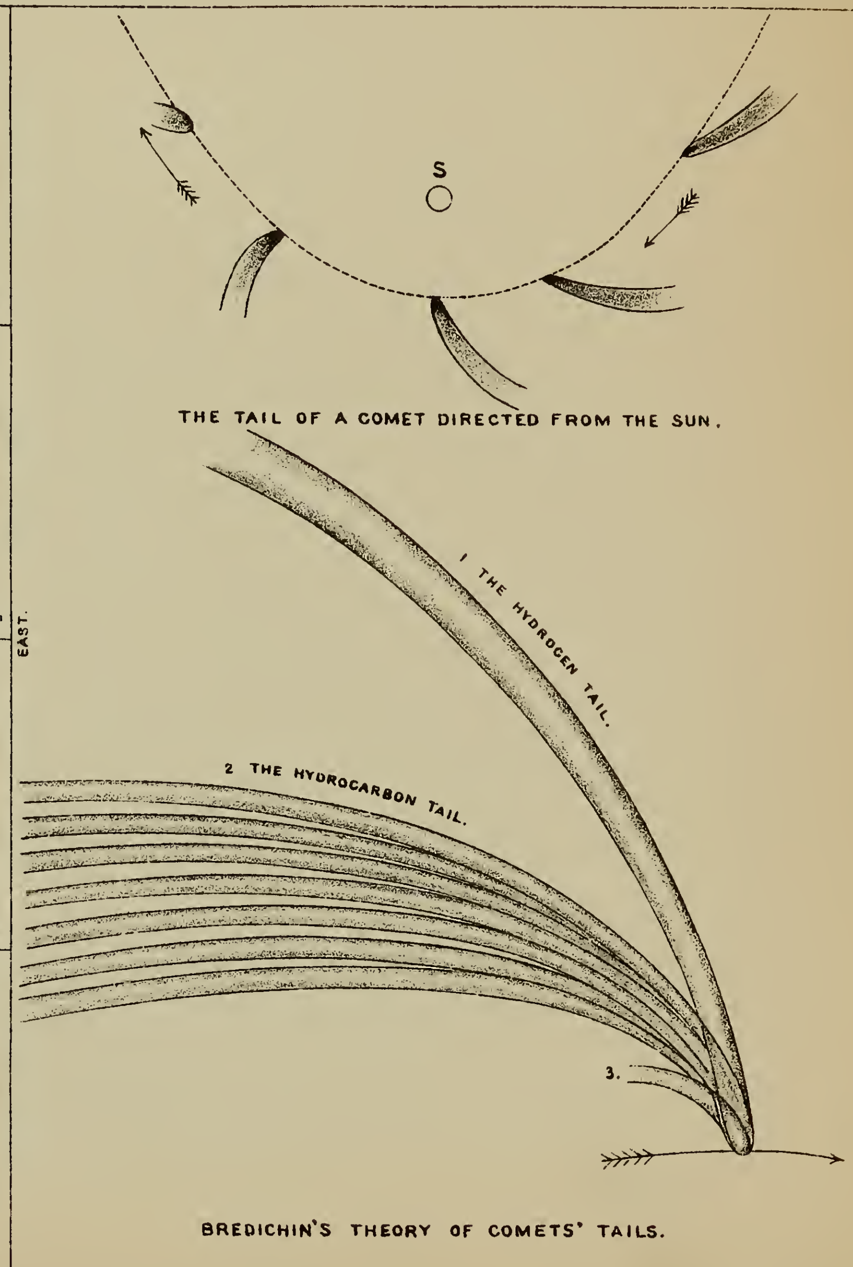
H. Lagrange Peninsula.
I. Secchi Continent.
J. Gill Land.
K. Webb Land.
L. Noble Cape.
M. Fontana Land.
N. Niesten Isthmus.

V. Banks Cape.
W. Hirst Island.
X. Lockyer Island.
Y. Mitchell Mountains.
Z. Kunowski Land.
a. Phillips Land.
b. Proctor Cape.

25. Kaiser Sea.
26. Nasmyth Inlet.
27. Dawes Ocean.
28. Schmidt Bay.
29. Lambert Sea.
30. Arago Strait.
31. Herschel II. Inlet.
32. Dawes Forked Bay.
33. Burton Bay.

JUPITER & COMETS.





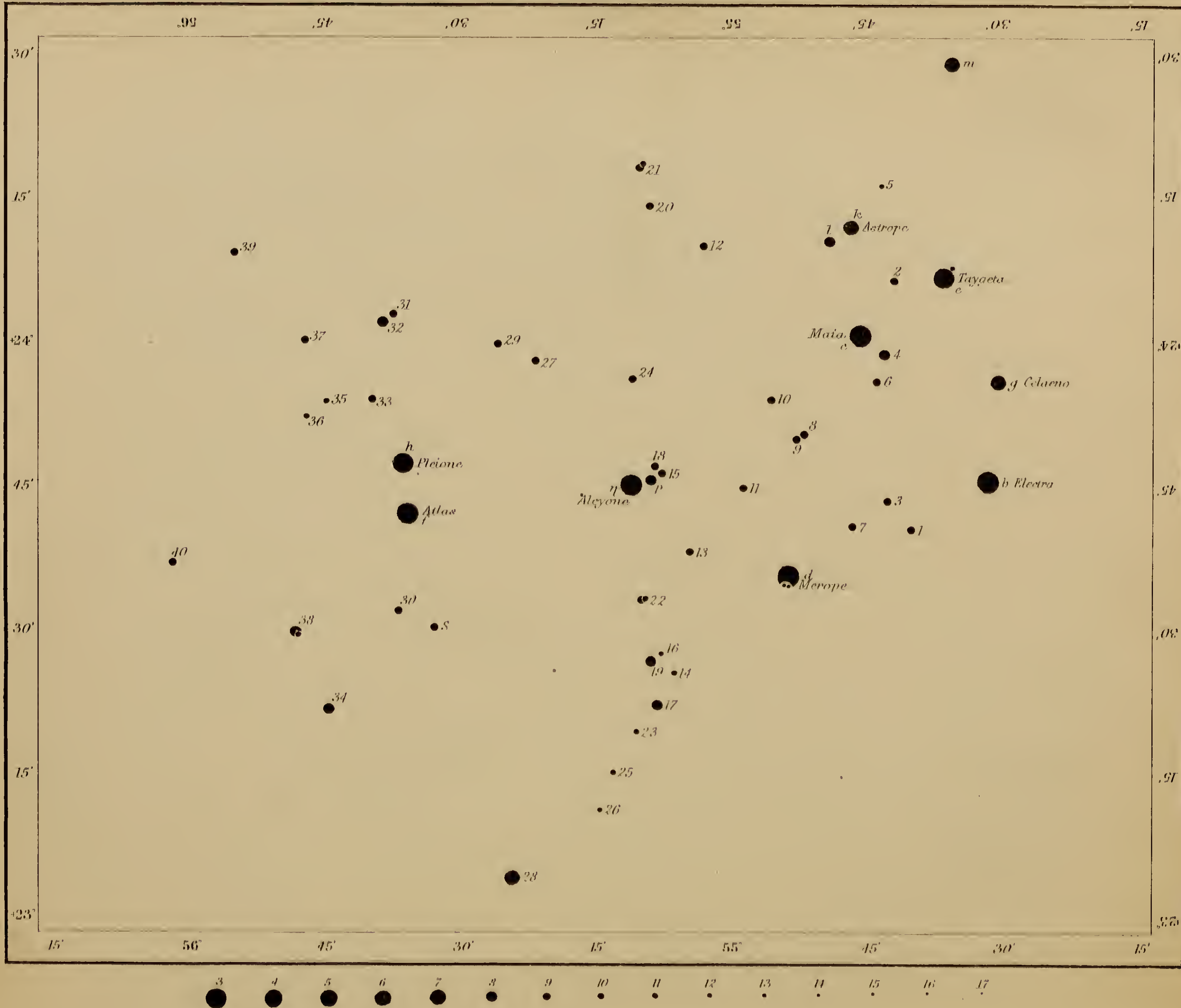
SATURN.

KEY MAP

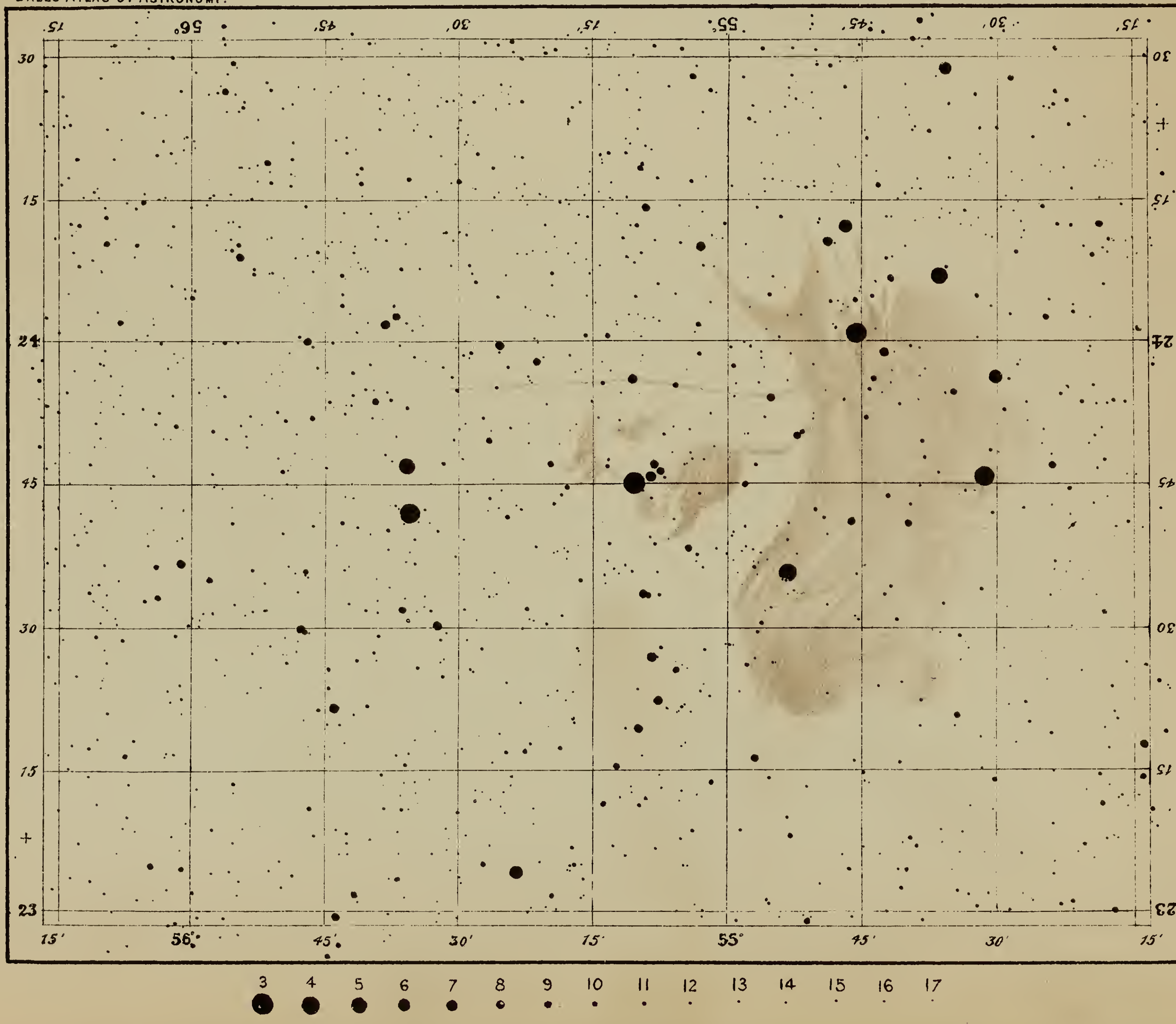
To face Plate 12

THE PLEIADES

Reproduction of a photograph taken by M.M.Paul and Prosper Henry.

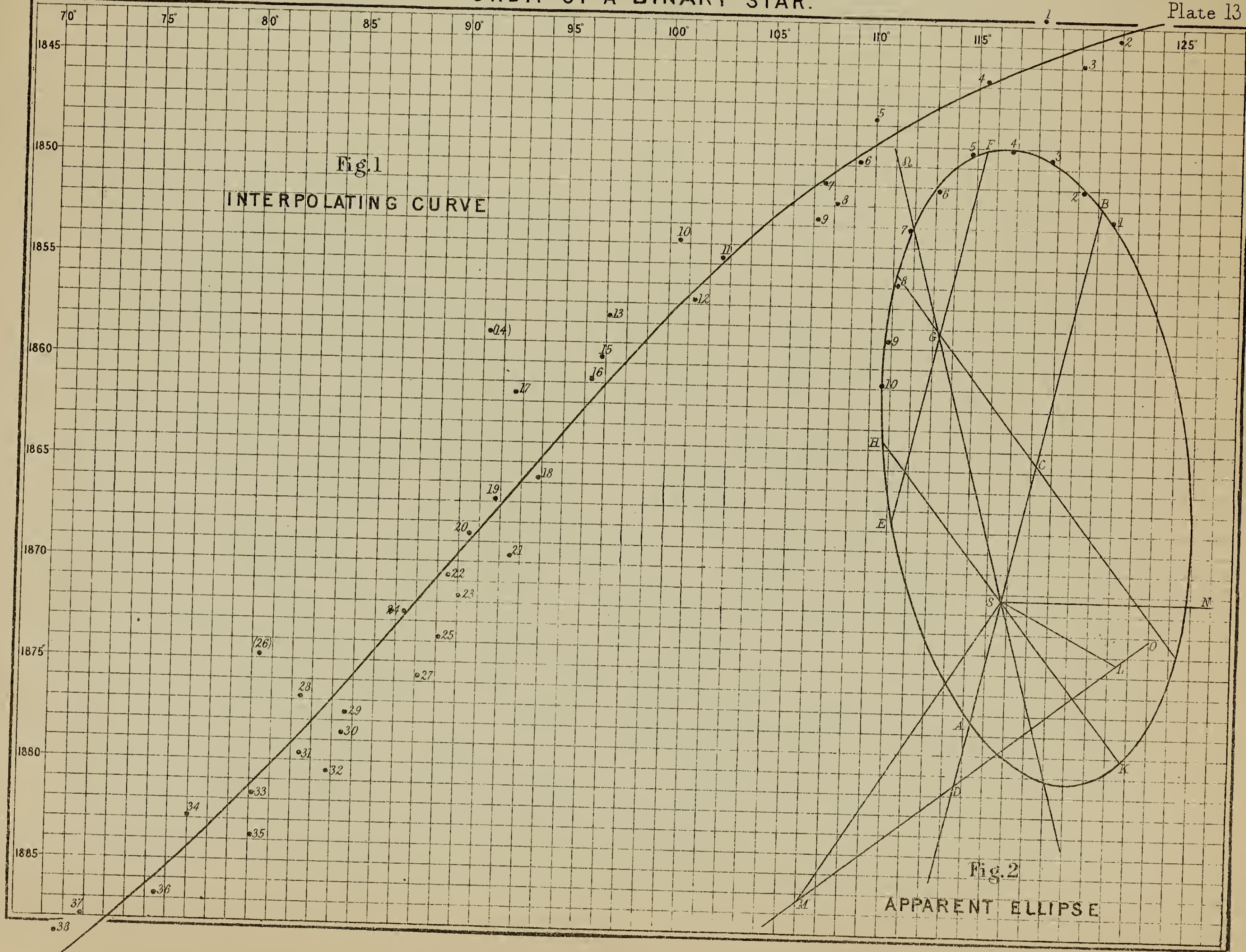


THE PLEIADES.



ORBIT OF A BINARY STAR.

Plate 13



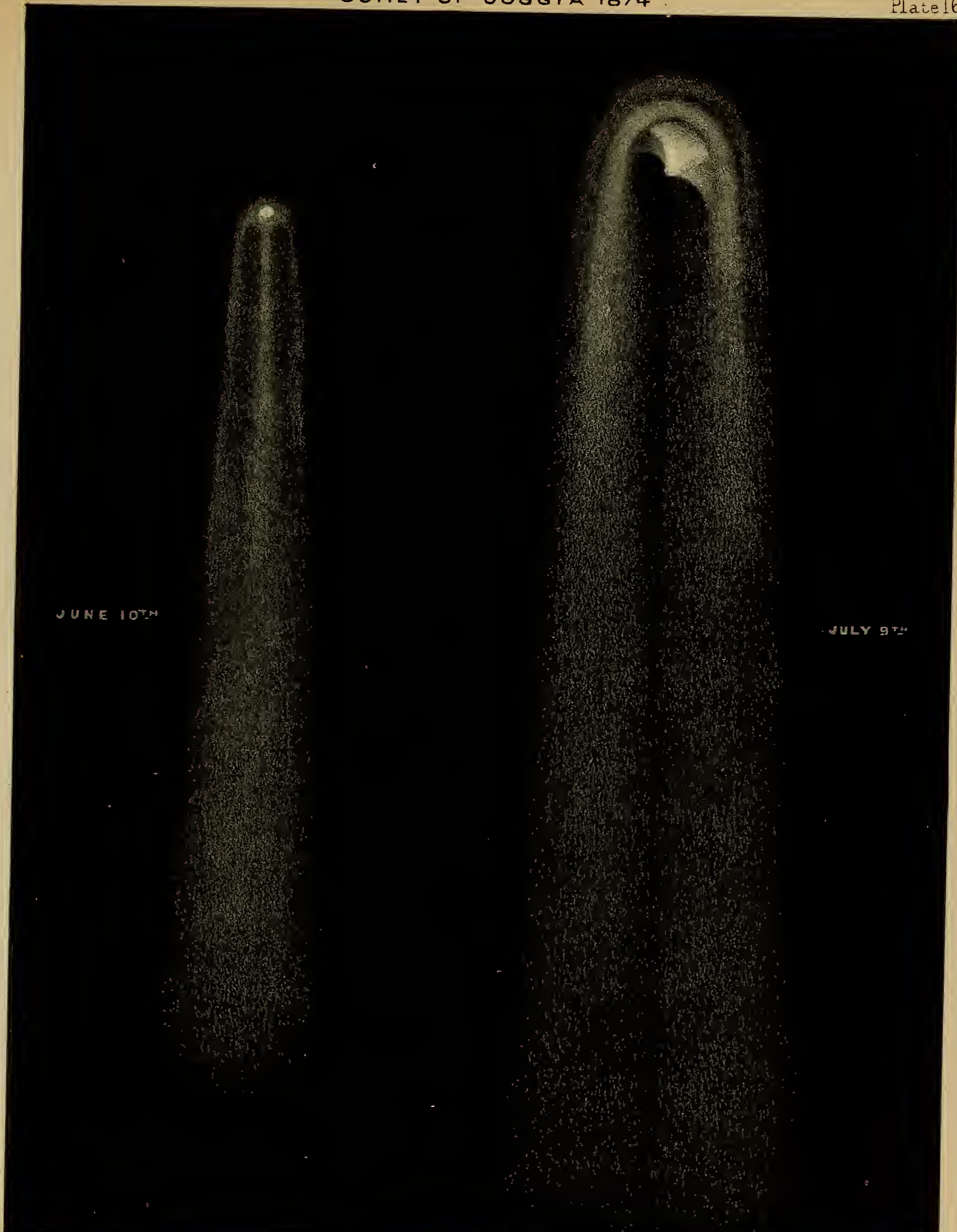
NEBULÆ.

ORION.

ANDROMEDA.

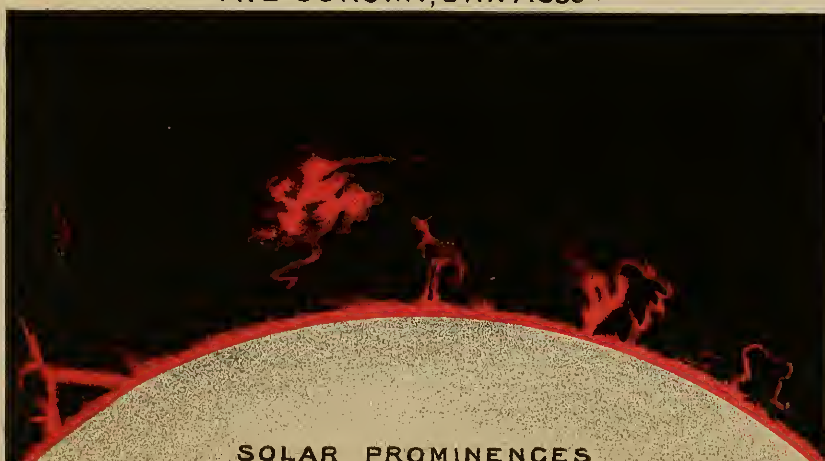
COMET OF DONATI OCT^{R} 5TH 1858.

COMET OF COGGIA 1874.

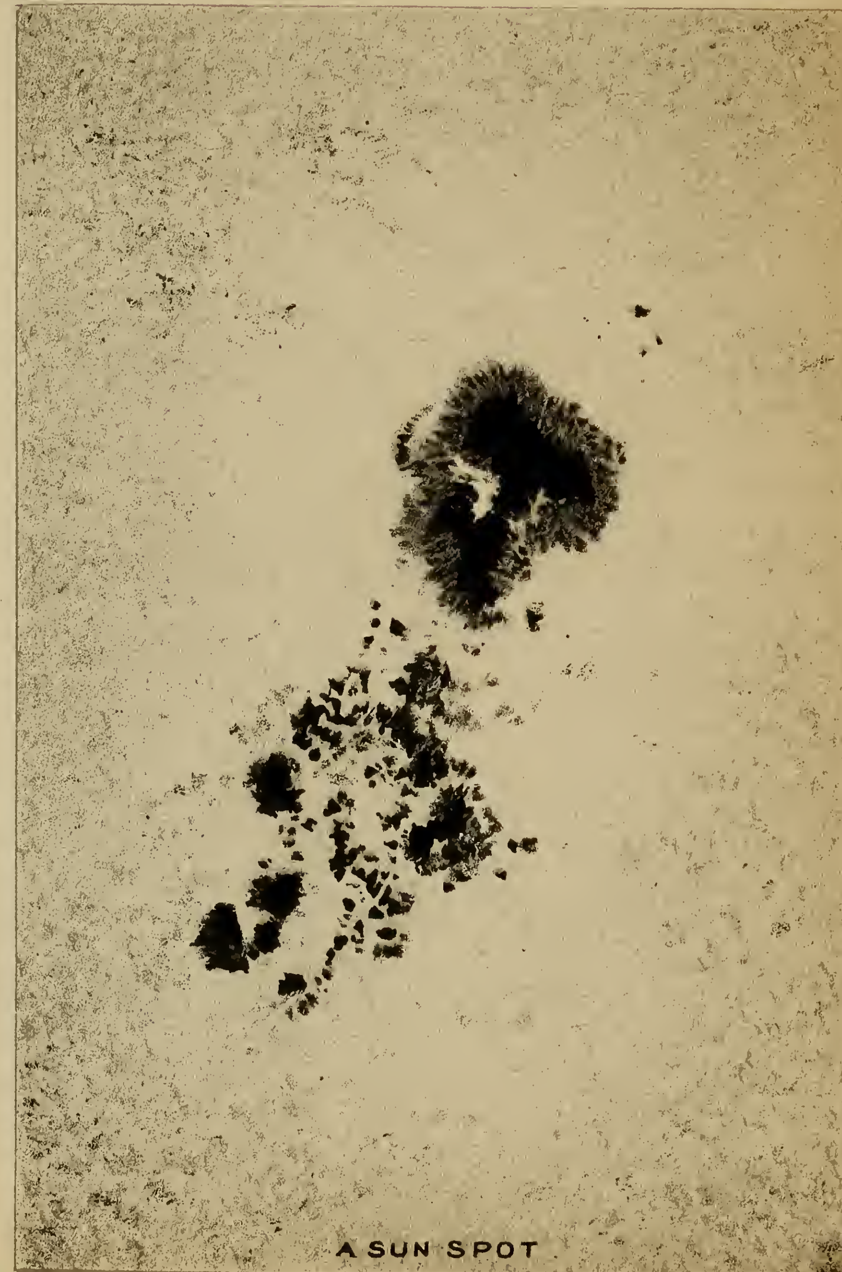


SOLAR PHENOMENA.

THE CORONA, JAN. 1889



SOLAR PROMINENCES.



A SUN SPOT.

PATHS OF SPOTS ACROSS THE SUN'S DISC.

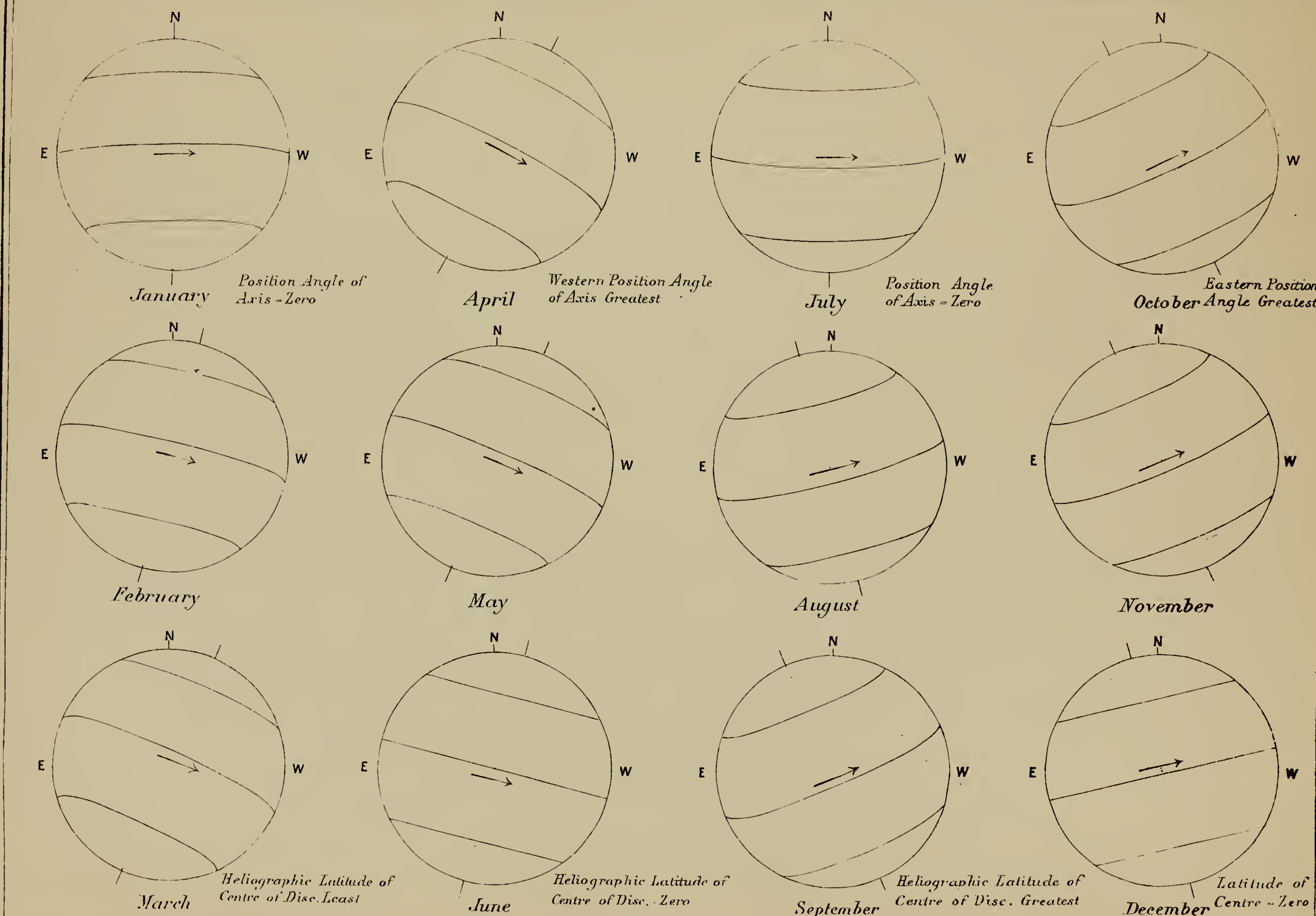


CHART FOR SUN-SPOT OBSERVATIONS Nº 1

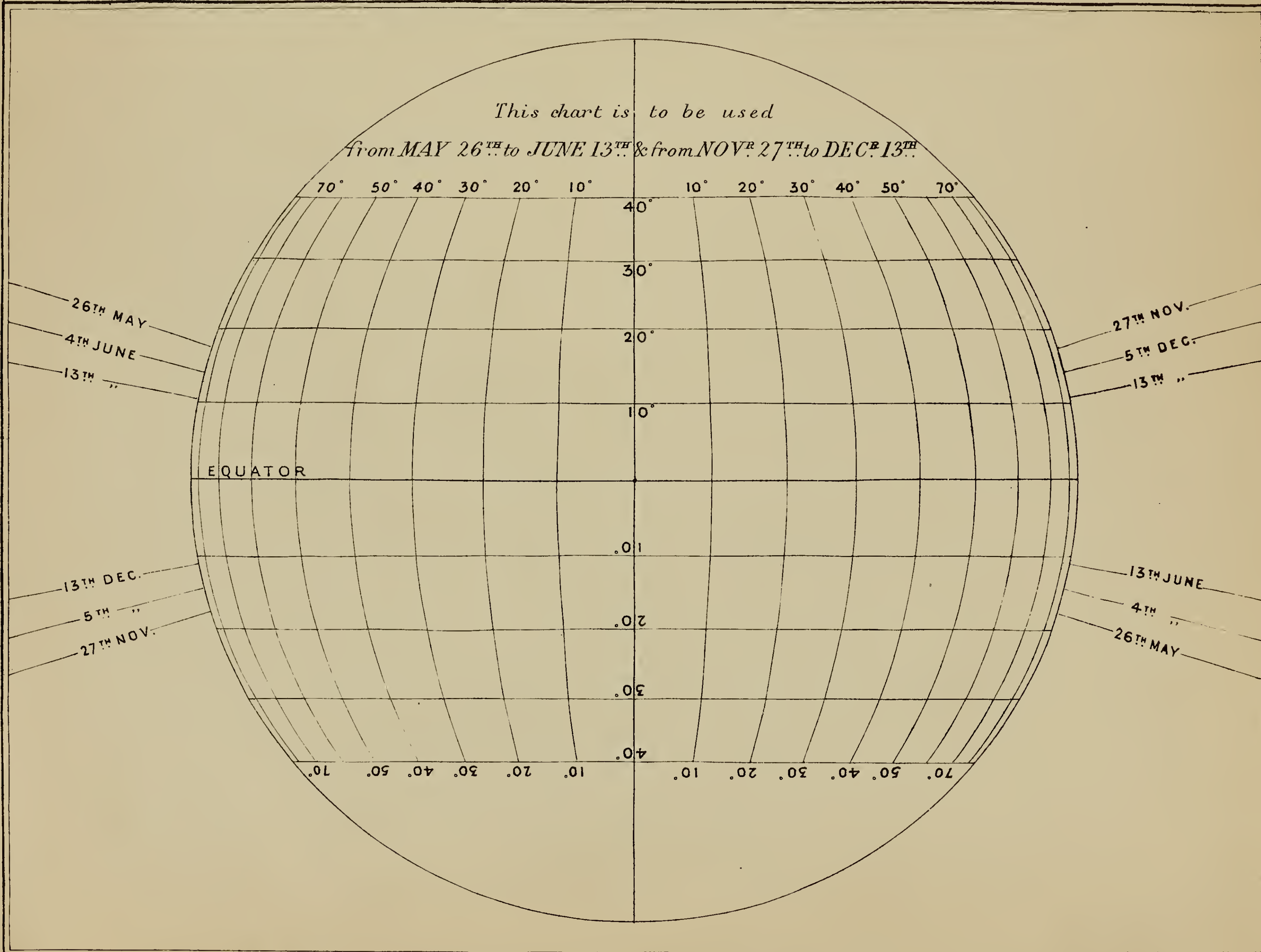
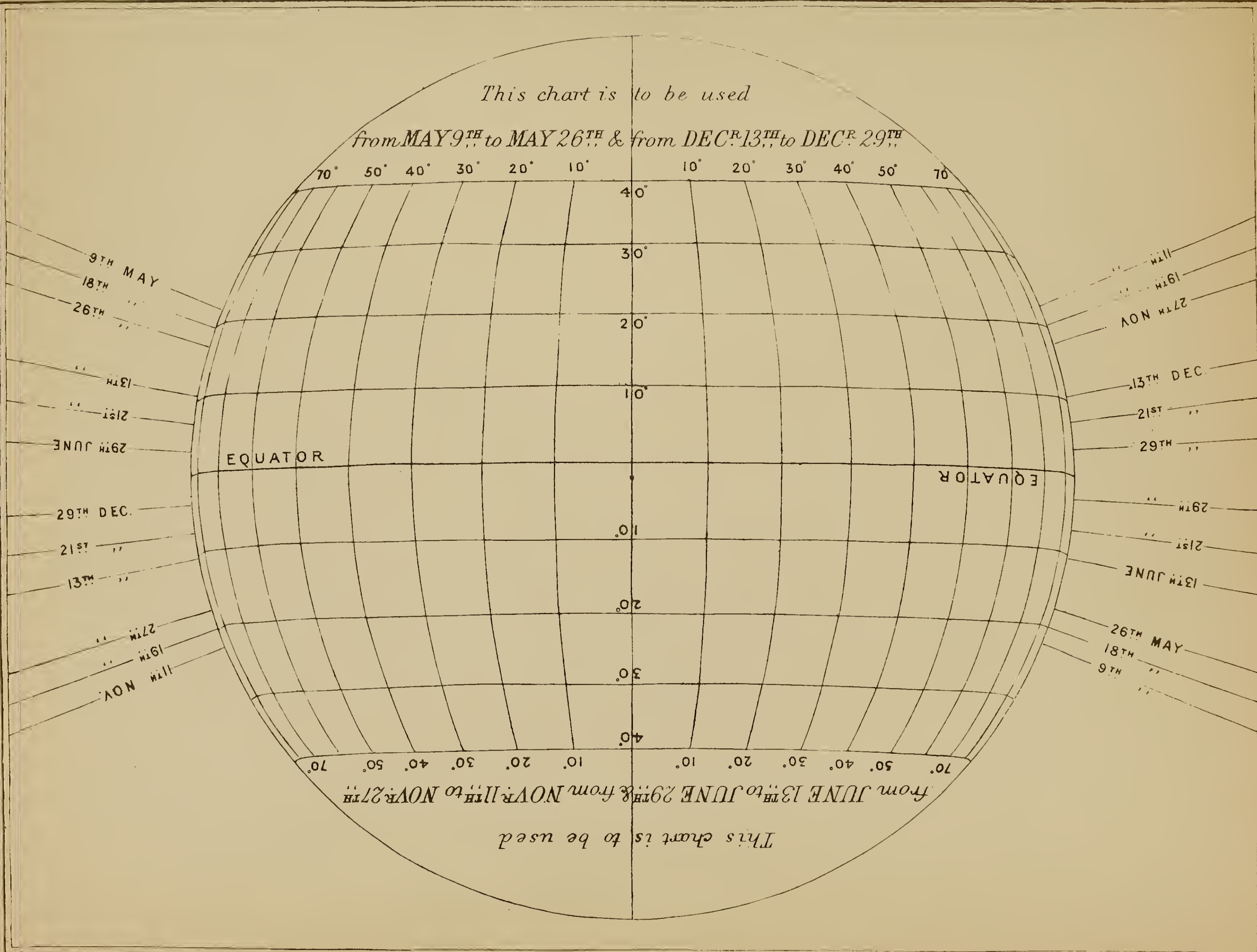


CHART FOR SUN-SPOT OBSERVATIONS Nº 2



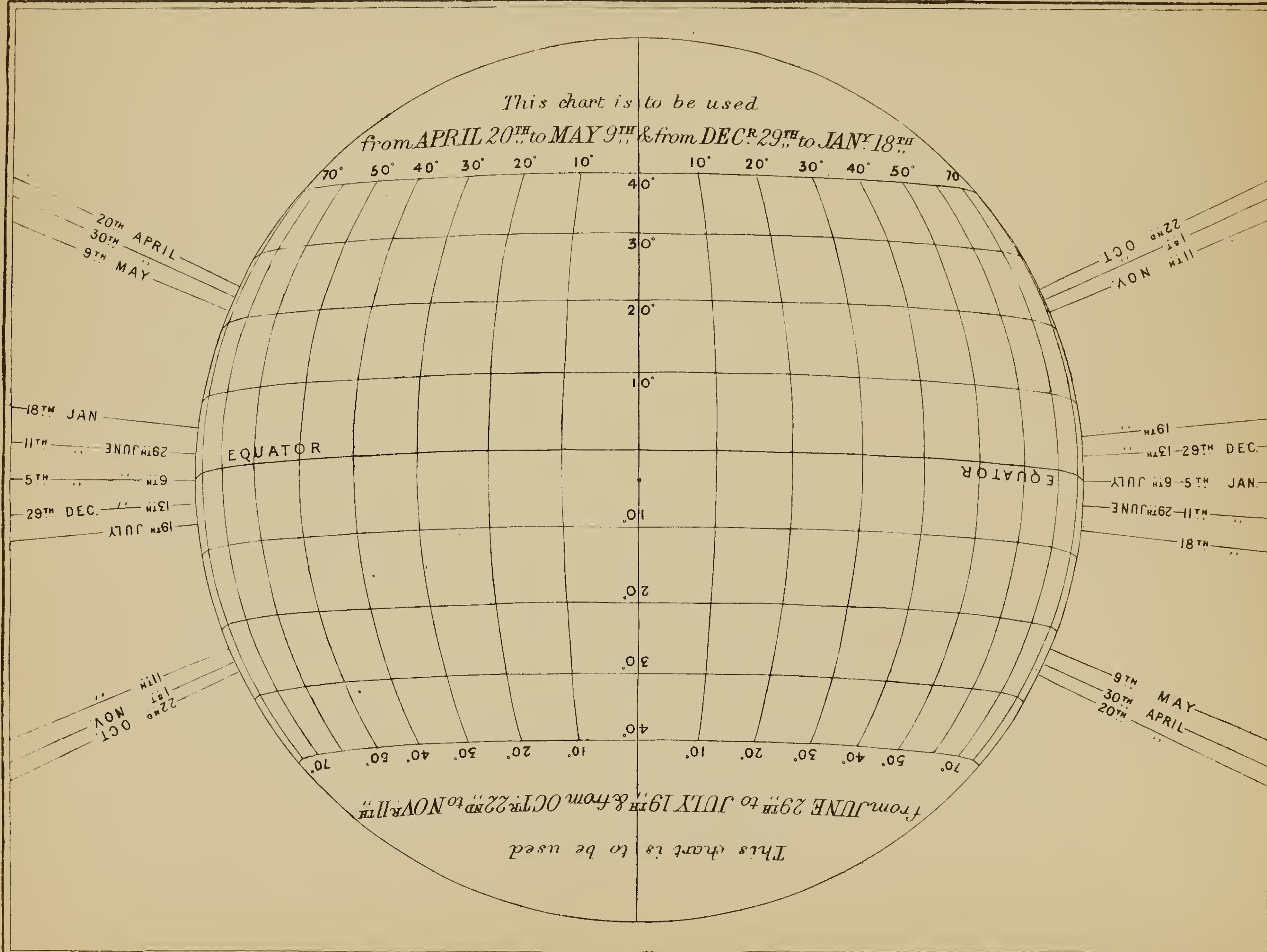
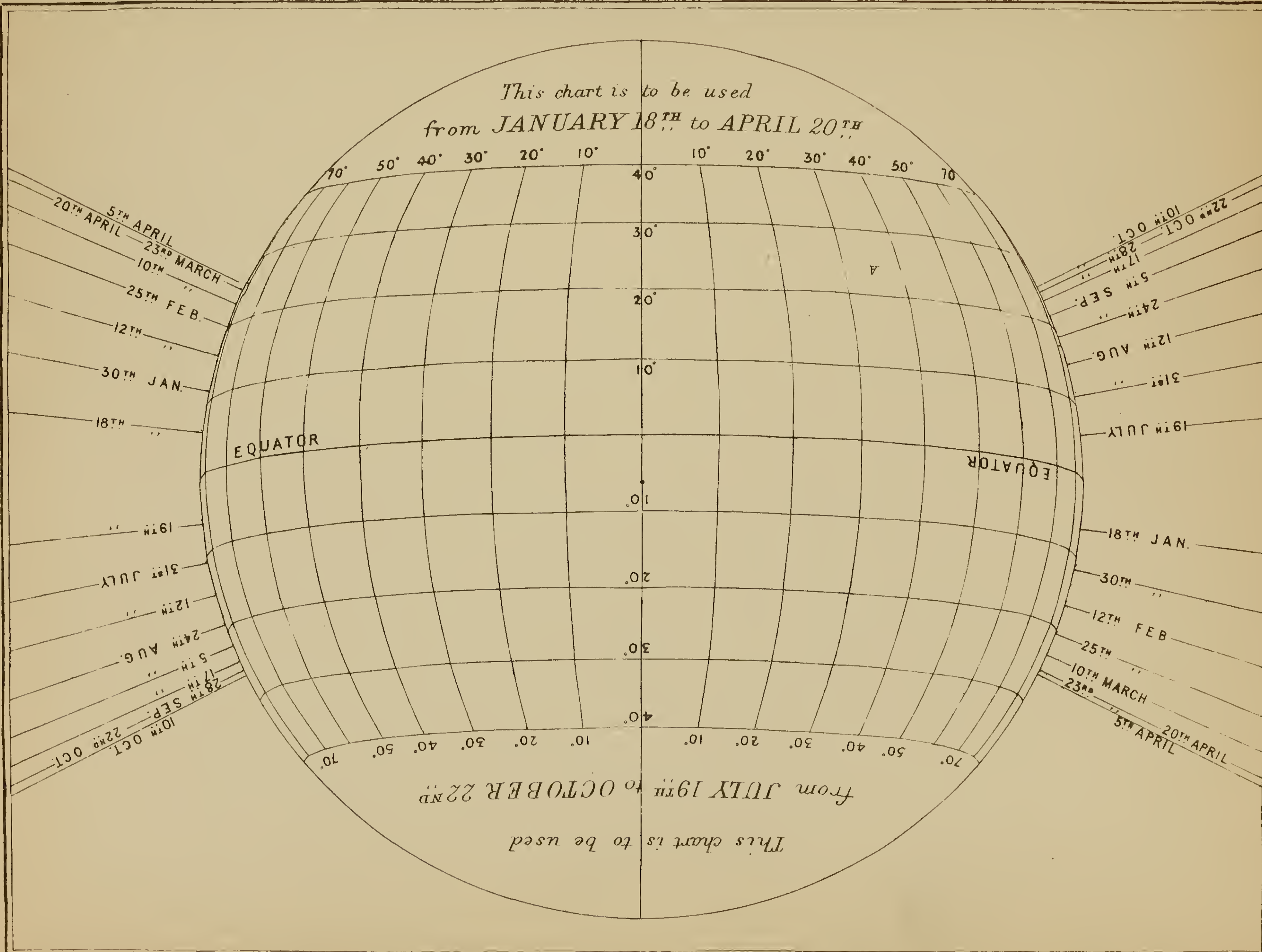

This chart is to be used
from APRIL 20TH to MAY 9TH & from DECR 29TH to JANY 18TH
This chart is to be used
from JUNE 29TH to JULY 19TH & from OCTR 22ND to NOVR 11TH
EQUATOR
EQUATOR
20TH APRIL
30TH
9TH MAY
18TH JAN.
11TH
29TH JUNE
5TH
6TH
29TH DEC.
13TH
19TH JULY
22ND OCT.
1ST
11TH NOV.
19TH
13TH—29TH DEC.
6TH JULY—5TH JAN.
29TH JUNE—11TH
18TH
9TH MAY
30TH
20TH APRIL
10° 20° 30° 40° 50° 70°

CHART FOR SUN-SPOT OBSERVATIONS No. 4



25. *Boussingault.*
22. *Pontécoulaut.*
19. *Fraunhofer.*

14. *Furnerius.*
12. *W. Humboldt.*
7. *Petavius.*

11. *Legendre.*
5. *Hecatæus.*
3. *Vendelinus.*
1. *Langrenus.*
2. *Kästner.*
136. *Apollonius.*
137. *Firmicus.*
139. *Neper.*
140. *Condorcet.*
152. *Picard.*
151. *Alhazen.*
153. *Peirce.*
167. *Cleomedes.*
169. *Burckhardt.*
173. *Geminus.*
172. *Gauss.*
175. *Messala.*
180. *Mercurius.*
188. *Endymion.*

A *Mare Crisium.*
B ,, *Fœcunditatis.*
C ,, *Australe.*
D ,, *Humboldtianum.*

26. *Boguslawsky.*
25. *Boussingault.*
22. *Pontécoulant.*

49. *Rosenberger.*
46. *Janssen.*
45. *Fabricius.*

44. *Metius.*
14. *Furnerius.*
15. *Stevinus.*
43. *Neander.*
41. *Reichenbach.*
16. *Snellius.*
7. *Petavius.*
36. *Santbech.*
34. *Colombo.*
3. *Vendelinus.*
31. *Godenius.*
32. *Guttemberg.*
1. *Langrenus.*
30. *Lubbock.*
29. *Messier.*
155. *Secchi.*
136. *Apollonius.*
154. *Taruntius.*
152. *Picard.*
153. *Peirce.*
156. *Proclus.*
166. *Macrobius.*
167. *Cleomedes.*
158. *Jansen.*
172. *Gauss.*
176. *Berzelius.*
175. *Messala.*
181. *Franklin.*
185. *Chevallier.*
186. *Atlas.*
180. *Mercurius.*
188. *Endymion.*
189. *De la Rue.*

A *Mare Crisium.*
B ,, *Faecunditatis.*
C ,, *Australe.*
D ,, *Humboldtianum.*

V *Palus Somnii.*

g. *Pyrenees Mts.*

4TH DAY.

27. *Schomberger.*
54. *Manzinus.*
53. *Mutus.*

49. *Rosenberger.*
48. *Vlacq.*
52. *Pitiscus.*

46. *Janssen.*
45. *Fabricius.*
44. *Metius.*
14. *Furnerius.*
64. *Stiborius.*
63. *Piccolomini.*
62. *Fracastorius.*
36. *Santbech.*
7. *Petavius.*
3. *Vendelinus.*
31. *Godenius.*
32. *Guttemberg.*
1. *Langrenus.*
58. *Isidorus.*
57. *Capella.*
29. *Messier.*
159. *Vitruvius.*
160. *Maraldi.*
220. *Le Monnier.*
219. *Chacornac.*
218. *Posidonius.*
214. *Plana.*
187. *Hercules.*
186. *Atlas.*
188. *Endymion.*
189. *De la Rue.*
198. *Euctemon.*

A *Mare Crisium.*
B ,, *Fæcunditatis.*
E ,, *Tranquillitatis.*
F ,, *Nectaris.*

D *Mare Humboldtianum.*
G *Lacus Somniorum.*
H ,, *Mortis.*

g. *The Pyrenees.*
k. *Taurus Mts.*

126. *Bacon.*
121. *Maurolycus.*

71. *Buch.*
64. *Stiborius.*
65. *Riccius.*

66. *Rabbi Levi.*
67. *Zagut.*
63. *Piccolomini.*
93. *Pons.*
62. *Fracastorius.*
90. *Sacrobosco.*
91. *Fermat.*
81. *Catharina.*
82. *Tacitus.*
80. *Cyrillus.*
59. *Mädler.*
79. *Theophilus.*
72. *Hypatia.*
247. *Sabine.*
246. *Ritter.*
250. *Arago.*
229. *Maclear.*
228. *Ross.*
227. *Plinius.*
226. *Dawes.*
236. *Bessel.*
220. *Le Monnier.*
219. *Chacornac.*
218. *Posidonius.*
208. *Eudoxus.*
207. *Aristoteles.*
197. *Meton.*
202. *Scoresby.*

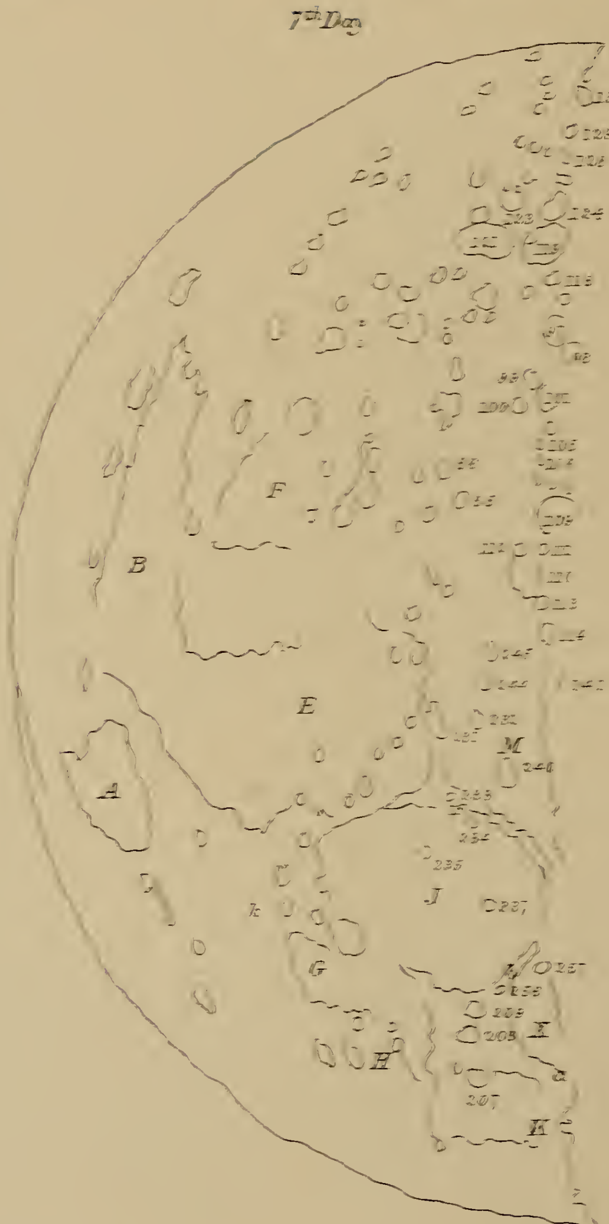
A *Mare Crisium.*
B ,, *Fœcunditatis.*
D ,, *Humboldtianum.*
E ,, *Tranquillitatis.*

F *Mare Nectaris.*
G *Lacus Somniorum.*
H ,, *Mortis.*
J *Mare Serenitatis.*

g. *The Pyrenees.*
h. *Altai Mts.*
k. *Taurus Mts.*
s. *Mt. Argæus.*

6TH DAY.

132. *Curtius.*
129. *Zach.*
128. *Lilius.*
124. *Licetus.*
123. *Clairaut.*
121. *Maurolycus.*



119. *Stöfler.*
118. *Fernelius.*
97. *Aliacensis.*
98. *Werner.*
99. *Apianus.*
100. *Playfair.*
101. *Blanchinus.*
105. *Donati.*
106. *Airy.*
86. *Almanon.*
85. *Abulfeda.*
109. *Albategnius.*
112. *Hind.*
111. *Halley.*
110. *Hipparchus.*
113. *Horrocks.*
114. *Rhaeticus.*
245. *Godin.*
244. *Agrippa.*
242. *Triesnecker.*
232. *Boscovich.*
231. *Julius Cæsar.*
240. *Manilius.*
233. *Taquet.*
234. *Menelaus.*
235. *Sulpicius Gallus.*
237. *Linné.*
257. *Theaetetus.*
256. *Calippus.*
209. *Alexander.*
208. *Eudoxus.*
207. *Aristoteles.*

H *Lacus Mortis.*
X *Palus Nebularum.*
M *Mare Vaporum.*
b. *The Caucasus.*
i. *The Hæmus Mts.*
k. *The Taurus Mts.*

A *Mare Crisium.*
B ,, *Fœcunditatis.*
E ,, *Tranquillitatis.*
G *Lacus Somniorum.*
F *Mare Nectaris.*
K ,, *Frigoris.*
M ,, *Vaporum.*
J ,, *Serenitatis.*

300. *Moretus.*
297. *Deluc.*
296. *Maginus.*
290. *Saussure.*
116. *Walter.*
285. *Ball.*
278. *Regiomontanus.*
277. *Purbach.*
274. *Thebit.*
266. *Arzachel.*
267. *Alpetragius.*
265. *Alphonsus.*
264. *Ptolemæus.*
263. *Herschel.*
261. *Mösting.*
373. *Sömmering.*
374. *Schröter.*
375. *Pallas.*
260. *Autolycus.*
399. *Archimedes.*
257. *Theætetus.*
259. *Aristillus.*
258. *Cassini.*
211. *Great Alpine Valley.*
413. *Plato.*
414. *Timæus.*
416. *Epigenes.*
417. *Goldschmidt.*

P *Sinus Medii.*
M ,, *Æstuum.*
J *Mare Serenitatis.*
L ,, *Imbrium.*
X *Palus Nebularum.*
Z ,, *Putredinis.*
K *Mare Frigoris.*
a. *The Alps.*
b. *The Caucasus.*
c. *The Apennines.*

300. *Moretus.*
299. *Cysatus.*
298. *Clavius.*

296. *Maginus.*
294. *Longomontanus.*
291. *Tycho.*

293. *Wilhelm I.*
292. *Heinsius.*
282. *Gauricus.*
283. *Wurzelbauer.*
280. *Sasserides.*
281. *Hesiodus.*
275. *Straight Wall.*
344. *Nicollet.*
274. *Thebit.*
266. *Arzachel.*
267. *Alpetragius.*
265. *Alphonsus.*
264. *Ptolemæus.*
270. *Guerike.*
271. *Parry.*
272. *Bonpland.*
262. *Lalande.*
273. *Fra Mauro.*
372. *Gambart.*
377. *Reinhold.*
381. *Stadius.*
380. *Copernicus.*
382. *Eratosthenes.*
383. *Gay Lussac.*
403. *Pytheas.*
401. *Timocharis.*
402. *Lambert.*
399. *Archimedes.*
413. *Plato.*
419. *Fontenelle.*
417. *Goldschmidt.*
418. *Anaxagoras.*

K *Mare Frigoris.*
L ,, *Imbrium.*
N *Sinus Æstuum.*

P *Sinus Medii.*
Q *Mare Nubium.*

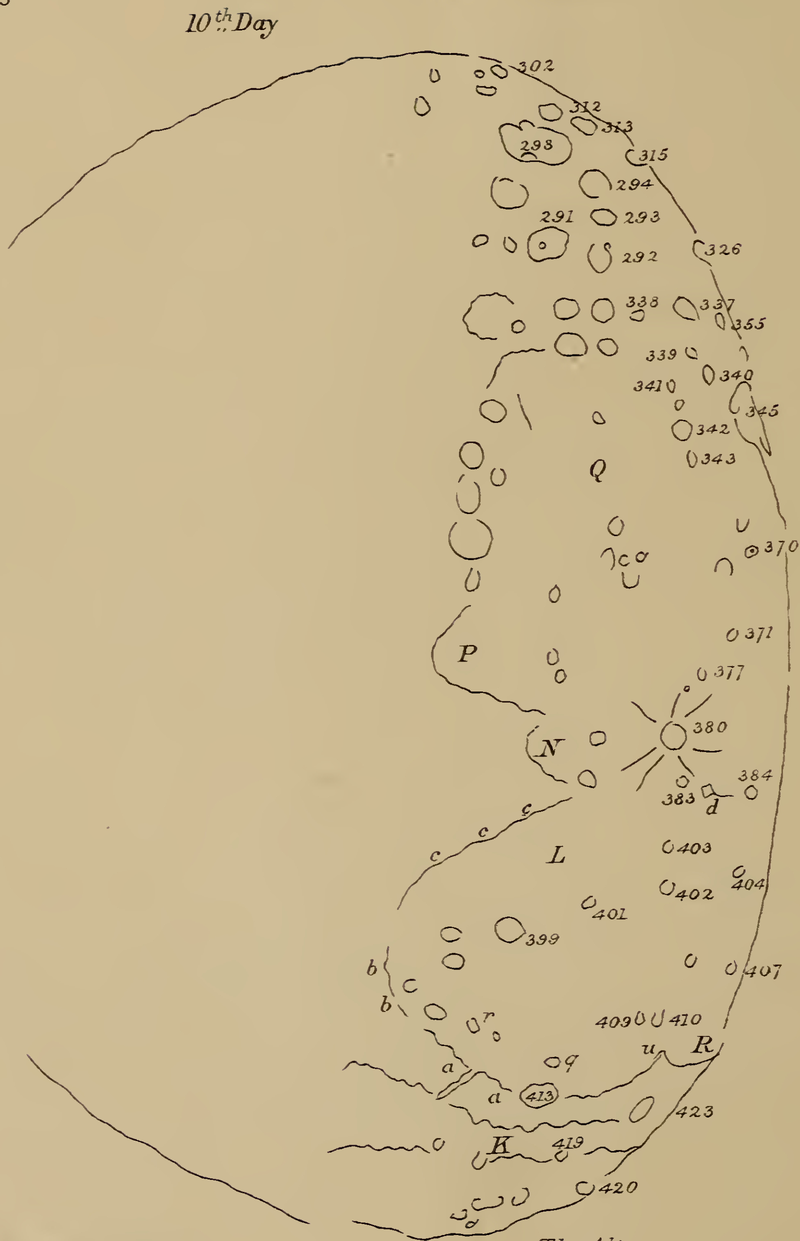
a. *The Alps.*
b. *The Caucasus Mts.*
c. *The Apennines.*

9TH DAY.

302. *Newton.*
312. *Blancanus.*
313. *Scheiner.*

298. *Clavius.*
315. *Rost.*
294. *Longomontanus.*

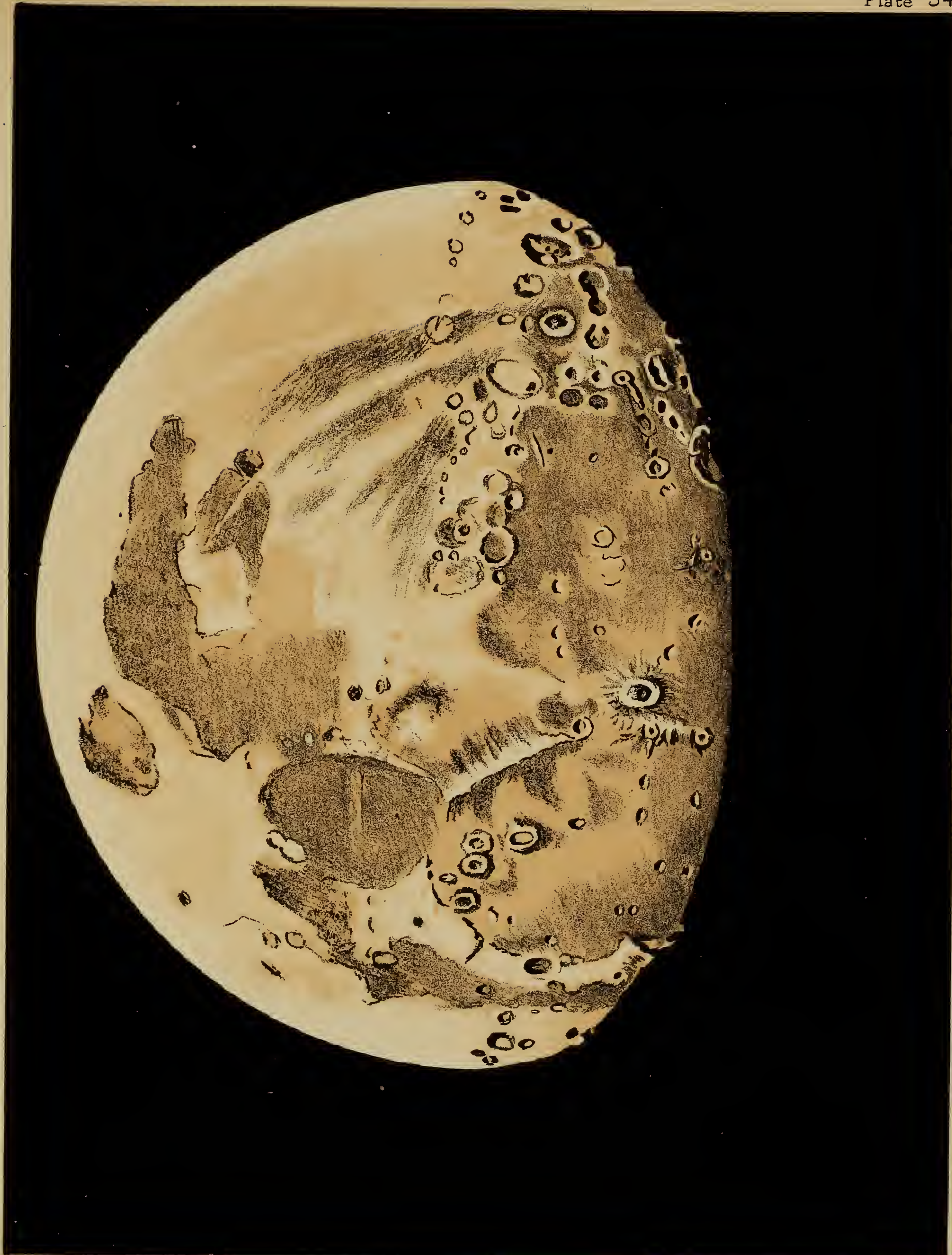
291. *Tycho.*
293. *Wilhelm I.*
292. *Heinsius.*
326. *Hainzel.*
338. *Cichus.*
337. *Capuanus.*
355. *Ramsden.*
339. *Mercator.*
340. *Campanus.*
341. *Kies.*
345. *Hippalus.*
342. *Bullialdus.*
343. *Lubiniezky.*
370. *Euclides.*
371. *Landsberg.*
377. *Reinhold.*
380. *Copernicus.*
384. *Tobias Mayer.*
383. *Gay Lussac.*
403. *Pytheas.*
402. *Lambert.*
404. *Euler.*
401. *Timocharis.*
399. *Archimedes.*
407. *Caroline Herschel.*
409. *Leverrier.*
410. *Helicon.*
413. *Plato.*
423. *Condamine.*
419. *Fontenelle.*
420. *Philolaus.*



K *Mare Frigoris.*
L ,, *Imbrium.*
P *Sinus Medii.*
Q *Mare Nubium.*
R *Sinus Iridum.*

a. *The Alps.*
b. *The Caucasus.*
c. *The Apennines.*
d. *The Carpathians.*
q. *Pico.*

r. *Piton.*
u. *Prom Laplace.*



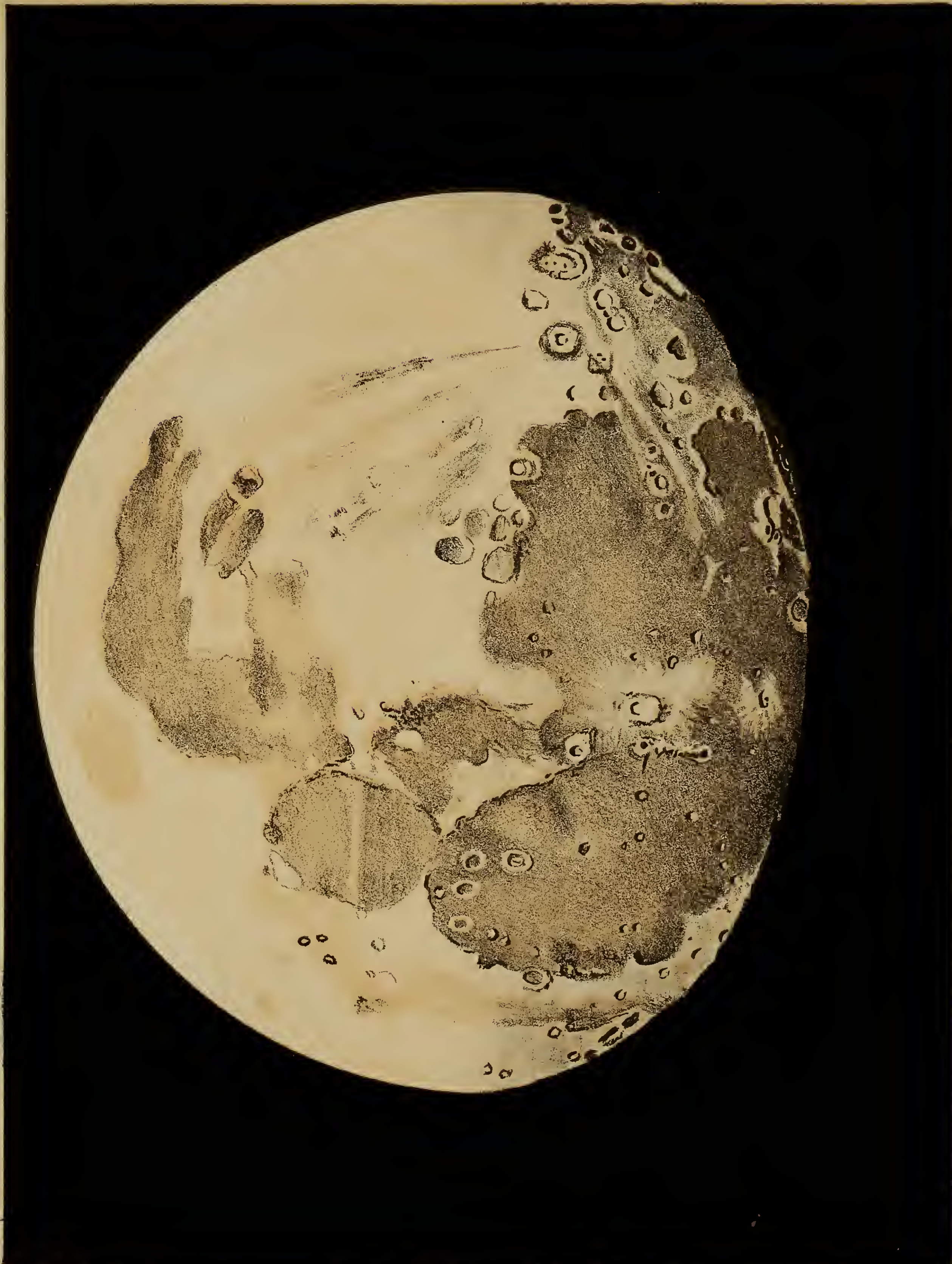
305. *Casatus.*
306. *Klaproth.*
307. *Wilson.*

309. *Bettinus.*
311. *Segner.*
313. *Scheiner.*

298. *Clavius.*
315. *Rost.*
317. *Schiller.*
318. *Bayer.*
326. *Hainzel.*
337. *Capuanus.*
355. *Ramsden.*
335. *Vitello.*
334. *Lee.*
333. *Doppelmayer.*
345. *Hippalus.*
346. *Agatharchides.*
347. *Gassendi.*
348. *Herigonius.*
349. *Letronne.*
370. *Euclides.*
369. *Wichmann.*
368. *Flamsteed.*
371. *Landsberg.*
385. *Kunowsky.*
377. *Reinhold.*
386. *Encke.*
378. *Hortensius.*
387. *Kepler.*
380. *Copernicus.*
379. *Milichius.*
384. *Tobias Mayer.*
383. *Gay Lussac.*
404. *Euler.*
402. *Lambert.*
401. *Timocharis.*
399. *Archimedes.*
405. *Diophantus.*
406. *Delisle.*
451. *Gruithuisen.*
427. *Mairan.*
426. *Sharp.*
425. *Bianchini.*
423. *Condamine.*
413. *Plato.*
429. *Harpalus.*
430. *J.F.W.Herschel.*
420. *Philolaus.*
421. *Anaximenes.*
i. *Riphæan Mts.*
q. *Pico.*
r. *Piton Mountain.*
u. *Prom Laplace.*

L *Mare Imbrium.*
K ,, *Frigoris.*
Q ,, *Nubium.*
R *Sinus Iridum.*
S *Oceanus Procellarum.*
T *Mare Humorum.*

a. *The Alps.*
b. *The Caucasus.*
c. *The Apennines.*
d. *The Carpathians.*
e. *The Sinus Iridum Highlands.*

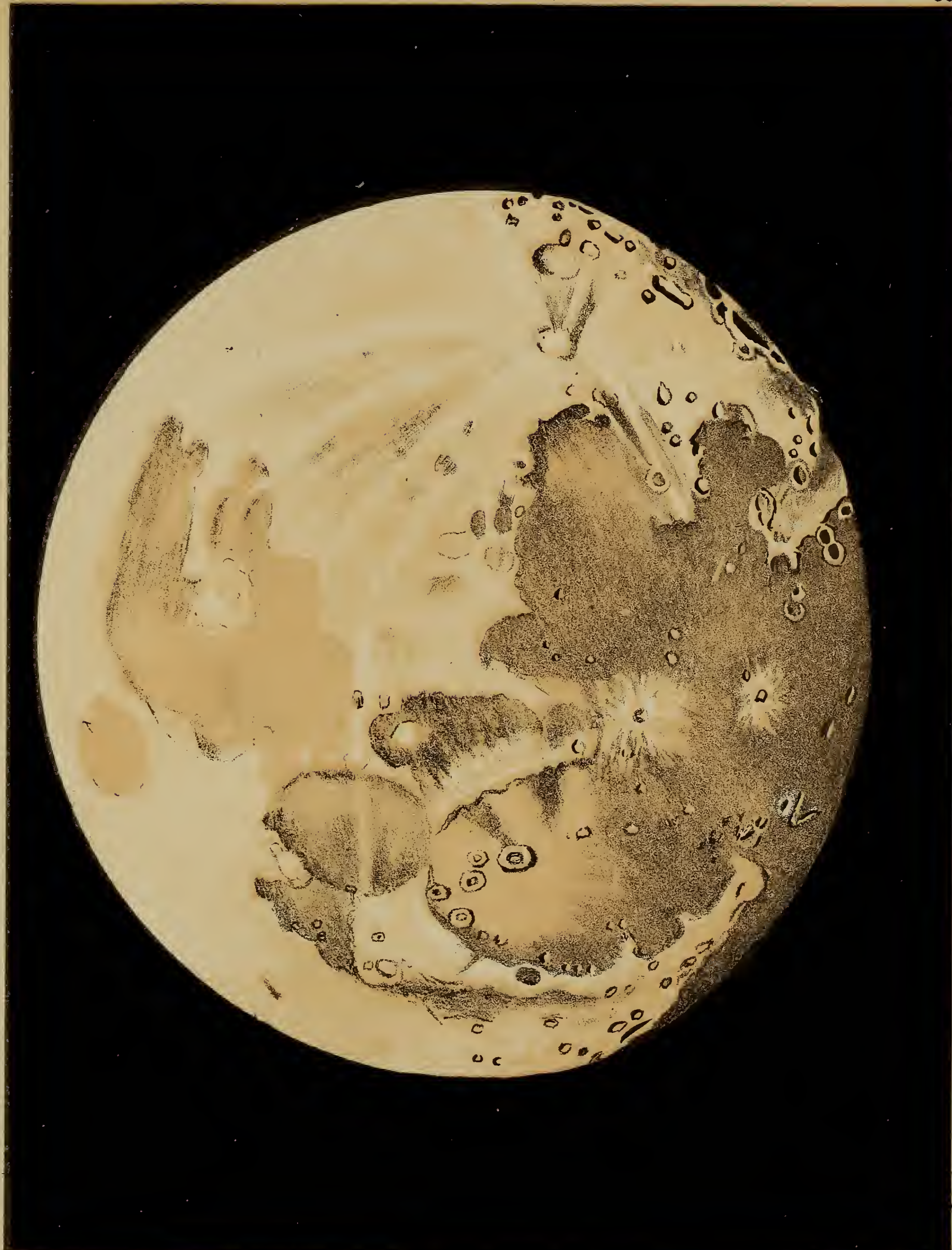


317. *Schiller.*
318. *Bayer.*
321. *Phocylides.*

323. *Schickard.*
327. *Lehmann.*
332. *Vieta.*

351. *Cavendish.*
350. *Mersenius.*
347. *Gassendi.*
359. *Fontana.*
356. *Billy.*
357. *Hansteen.*
349. *Letronne.*
368. *Flamsteed.*
386. *Encke.*
389. *Reiner.*
387. *Kepler.*
390. *Marius.*
447. *Aristarchus.*
448. *Herodotus.*
404. *Euler.*
449. *Wollaston.*
427. *Mairan.*
426. *Sharp.*
425. *Bianchini.*
423. *Condamine.*
419. *Fontenelle.*
431. *Anaximander.*
420. *Philolaus.*
421. *Anaximenes.*

K *Mare Frigoris.*
L ,, *Imbrium.*
Q *Mare Nubium.*
S *Oceanus Procellarum.*
T *Mare Humorum.*
e. *The Sinus Iridum Highlands.*
u. *Prom. Laplace.*



321. *Phocylides.*

322. *Wargentin.*

325. *Inghirami.*

323. *Schickard.*

329. *Piazzi.*

330. *Lagrange.*

332. *Vieta.*

351. *Cavendish.*

350. *Mersenius.*

359. *Fontana.*

361. *Crüger.*

362. *Rocca.*

363. *Grimaldi.*

366. *Lohrmann.*

391. *Hevel.*

392. *Cavalerius.*

397. *Seleucus.*

448. *Herodotus.*

447. *Aristarchus.*

445. *Briggs.*

432. *Pythagoras.*

L *Mare Imbrium.*

Q ,, *Nubium.*

R *Sinus Iridum.*

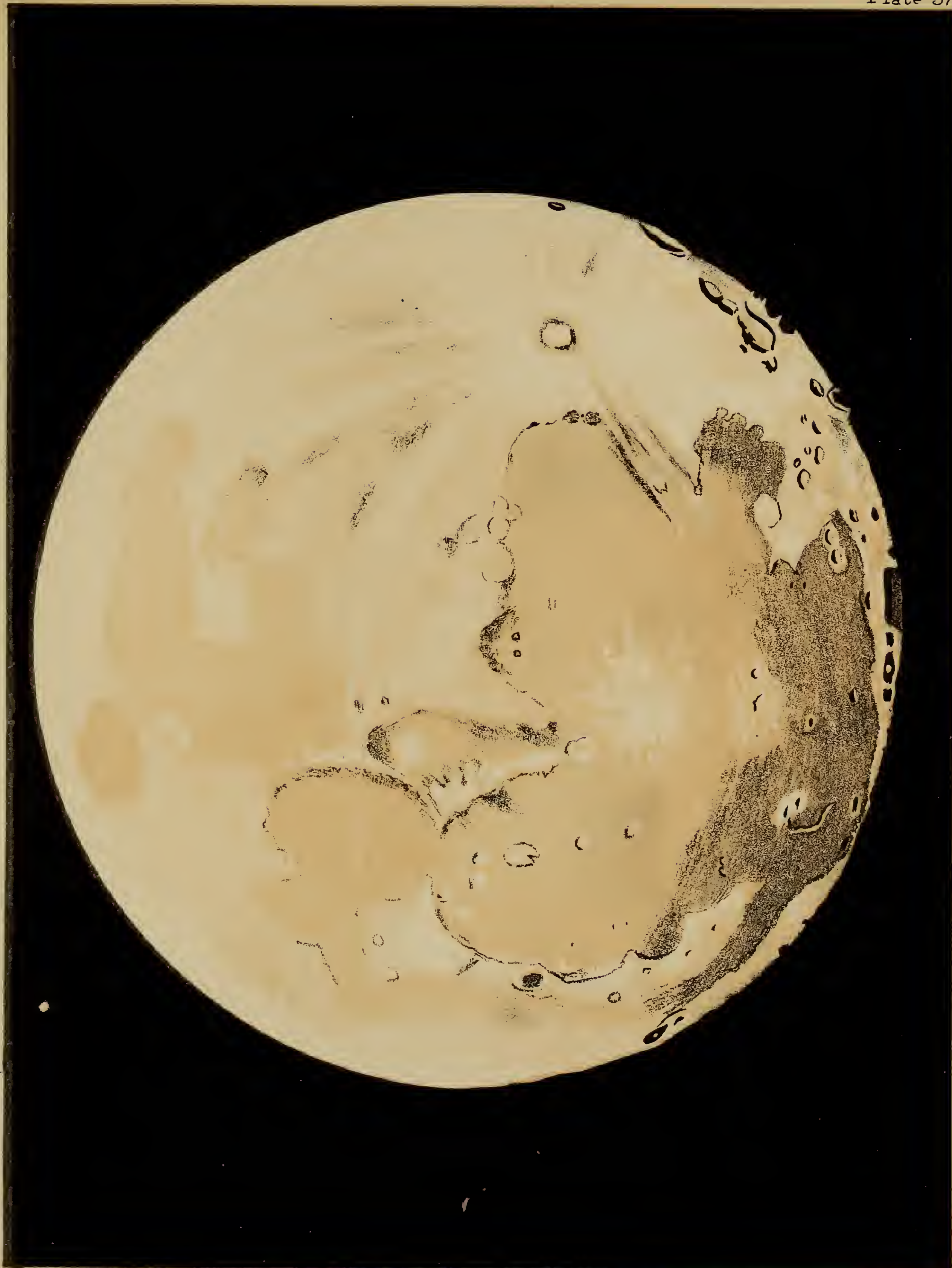
S *Oceanus Procellarum.*

T *Mare Humorum.*

W *Sinus Roris.*

e. *The Sinus Iridum Highlands.*

u. *Prom. Laplace.*



Key Map. THE MOON—14th Day. To face Plate 38.

316. *Bailly.*
321. *Phocylides.*
322. *Wargentin.*
325. *Inghirami.*
323. *Schickard.*
329. *Piazzi.*
330. *Lagrange.*
353. *Eichstädt.*
362. *Rocca.*
363. *Grimaldi.*
365. *Riccioli.*
366. *Lohrmann.*
391. *Hevel.*
392. *Cavalerius.*
393. *Olbers.*
394. *Cardanus.*
395. *Krafft.*
448. *Herodotus.*
447. *Aristarchus.*
397. *Seleucus.*
445. *Briggs.*
446. *Otto Struve.*
439. *Repsold.*
438. *Xenophanes.*
437. *Cleostratus.*
432. *Pythagoras.*

K *Mare Frigoris.*
L ,, *Imbrium.*
R *Sinus Iridum.*
S *Oceanus Procellarum.*
T *Mare Humorum.*
W *Sinus Roris.*

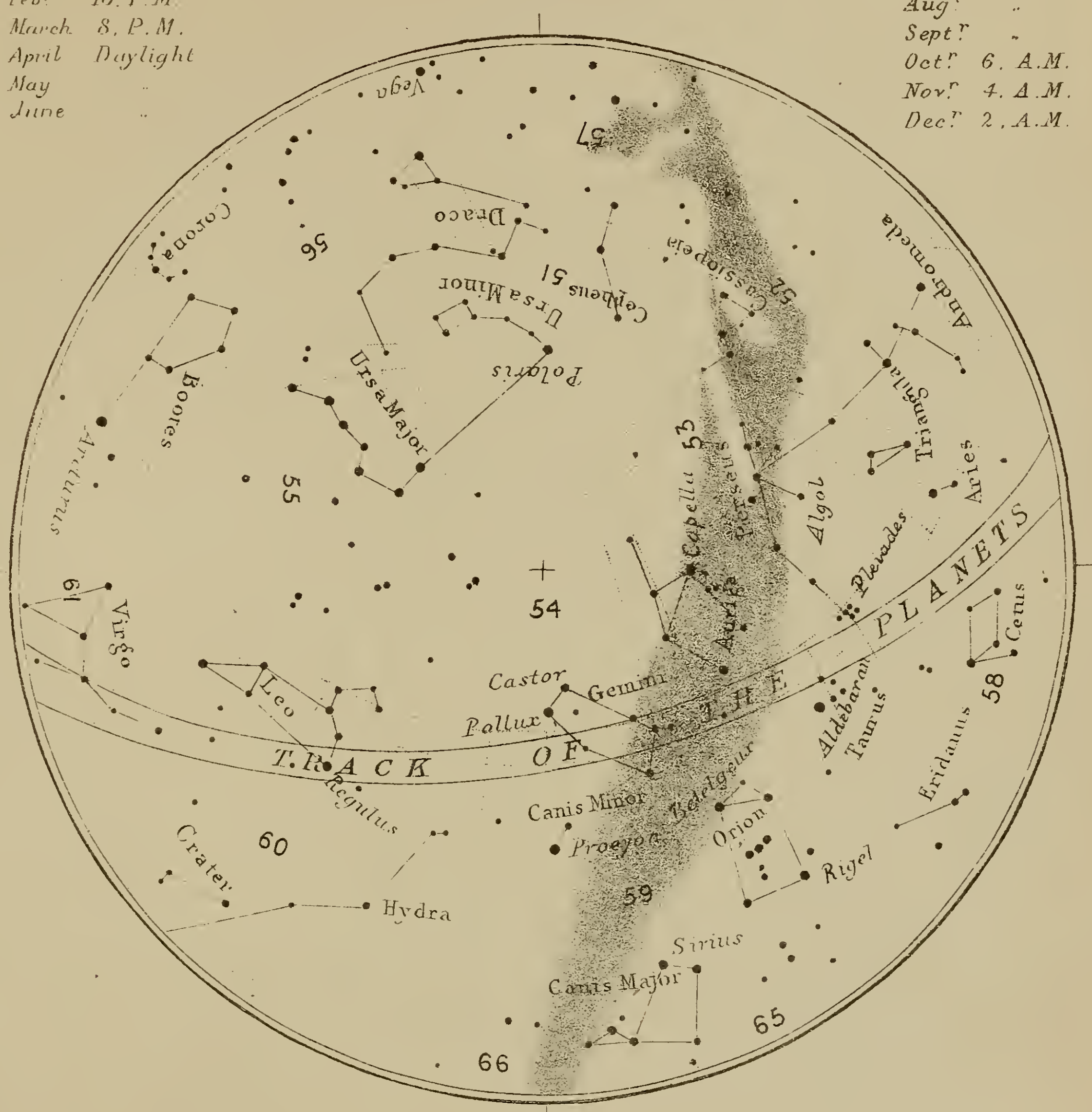
14 TH DAY.

January Midnight
and also as follows

Jan.ʸ	Midnight
Feb.ʸ	10. P.M.
March.	8. P.M.
April	Daylight
May	..
June	..

July	Daylight
Aug.ᵗ	..
Sept.ʳ	..
Oct.ʳ	6. A.M.
Nov.ʳ	4. A.M.
Dec.ʳ	2. A.M.

North



South

or at Sidereal Time 7ʰ 37ᵐ

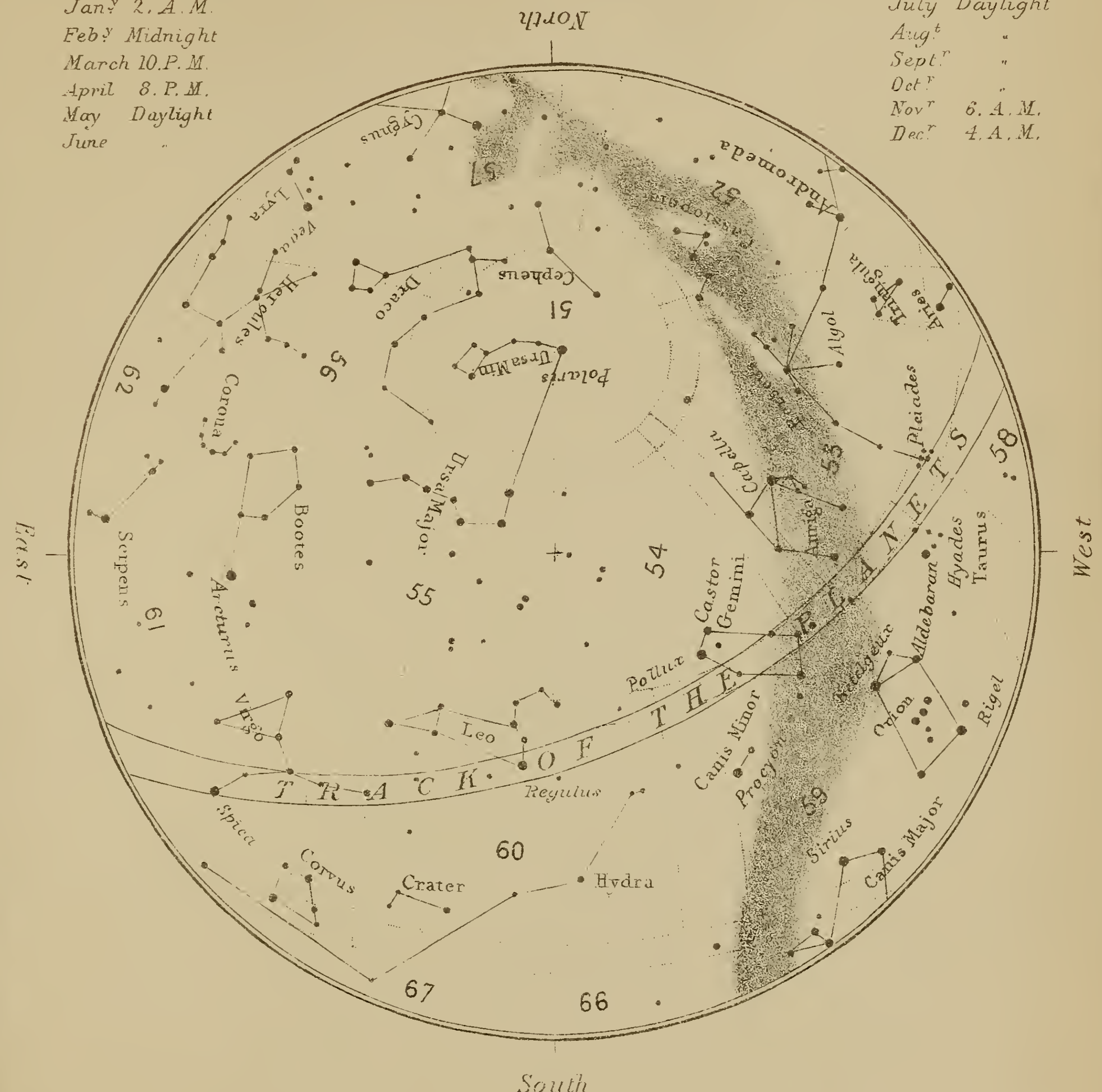
1 2 3 4

February Midnight

and also as follows

Jan.ʸ 2. A.M.	
Feb.ʸ Midnight	
March 10. P.M.	
April 8. P.M.	
May Daylight	
June "	

July	Daylight
Aug.ᵗ	"
Sept.ʳ	"
Oct.ʳ	"
Nov.ʳ	6. A.M.
Dec.ʳ	4. A.M.



or at Sidereal Time $9^h\ 37^m$

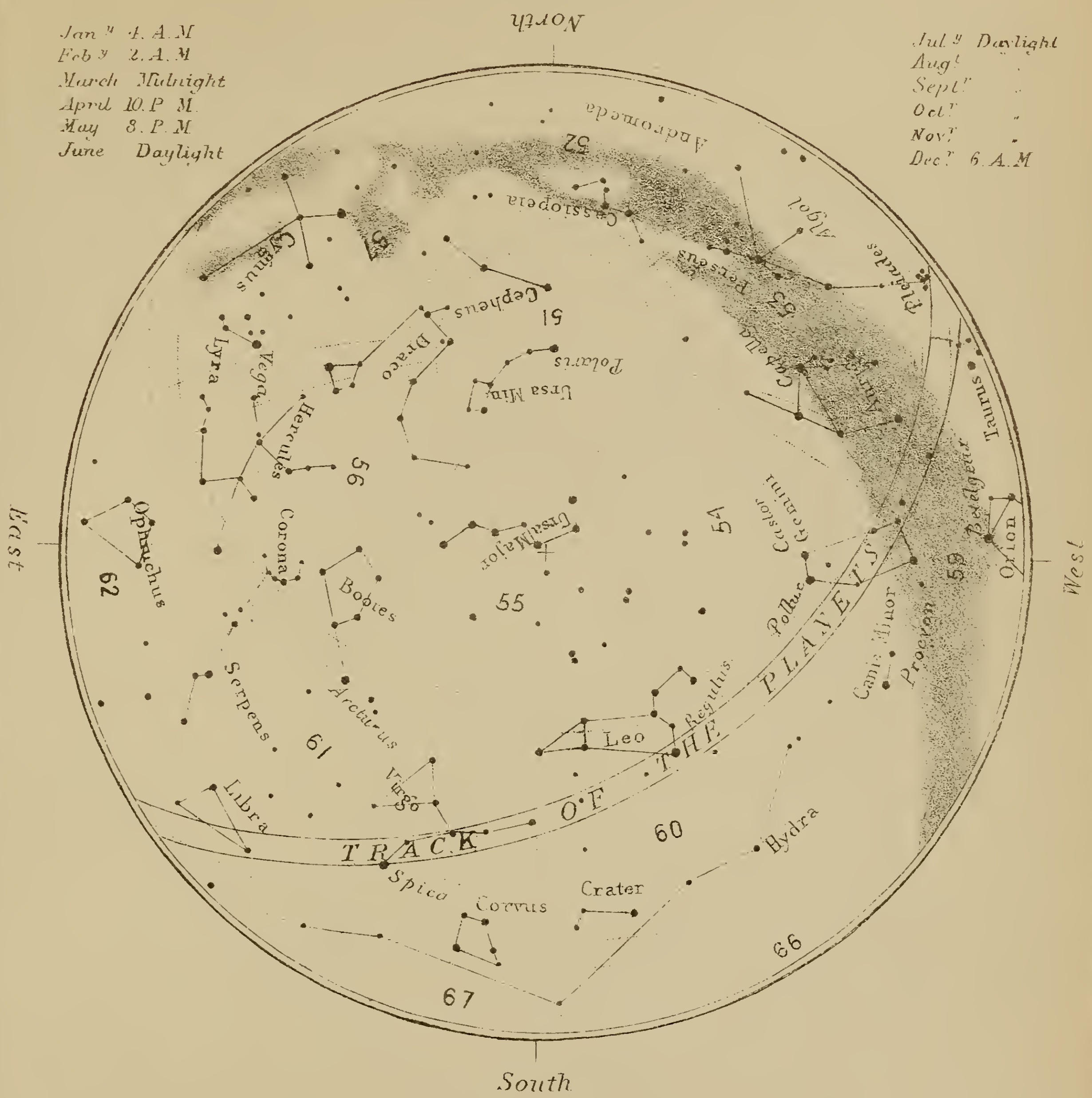
1 2 3 4

March Midnight

and also as follows

Jan.y	4. A. M
Feb.y	2. A. M
March	Midnight
April	10. P. M.
May	8. P. M.
June	Daylight

July	Daylight
Aug.t	"
Sept.r	"
Oct.r	"
Nov.r	"
Dec.r	6. A. M



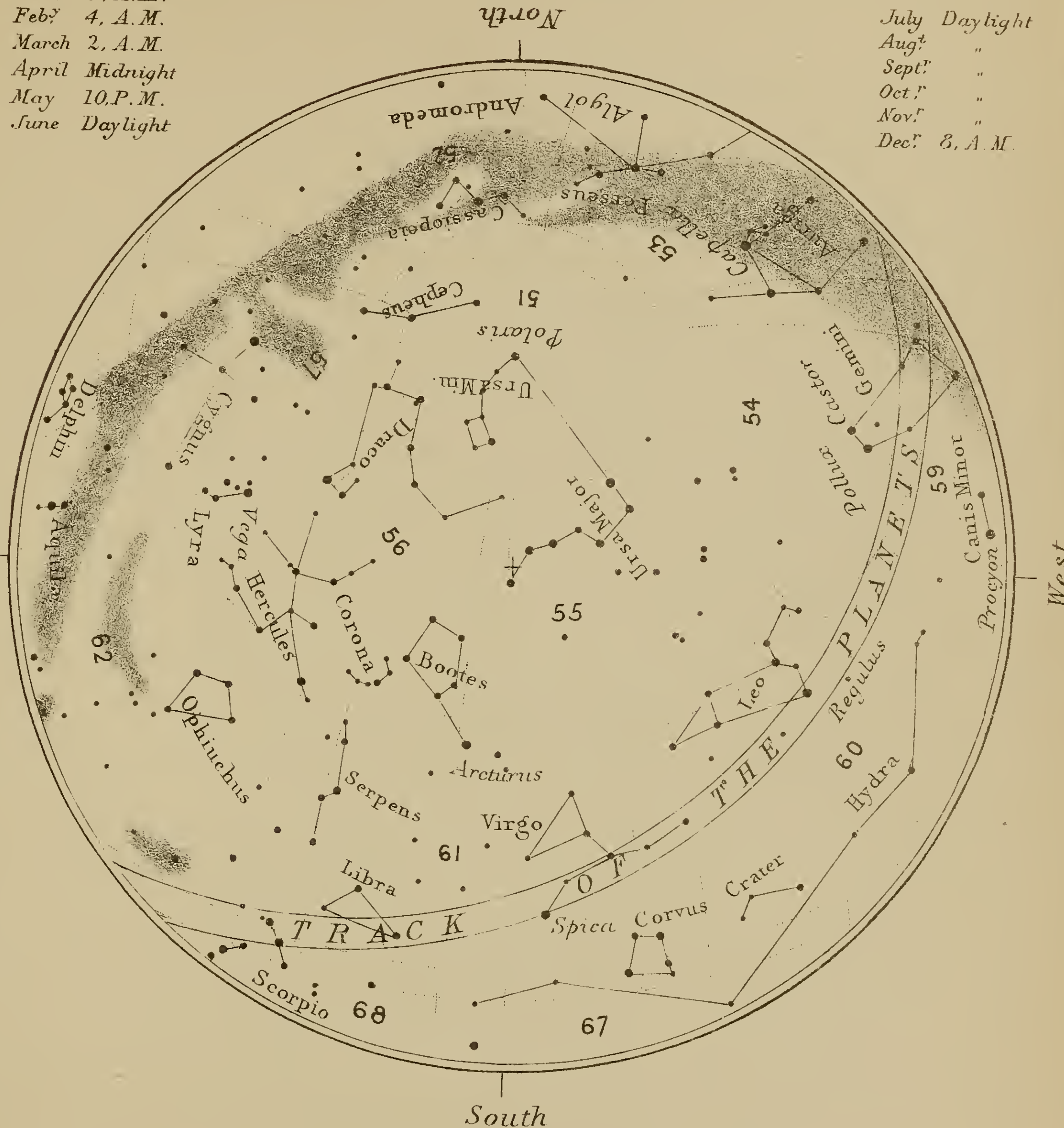
or at Sidereal Time $11^{h}\ 37^{m}$

1 2 3 4

April Midnight

and also as follows

Jan.y	6, A.M.
Feb.y	4, A.M.
March	2, A.M.
April	Midnight
May	10, P.M.
June	Daylight
July	Daylight
Aug.t	"
Sept.r	"
Oct.r	"
Nov.r	"
Dec.r	8, A.M.



or at Sidereal Time 13.h 37.m

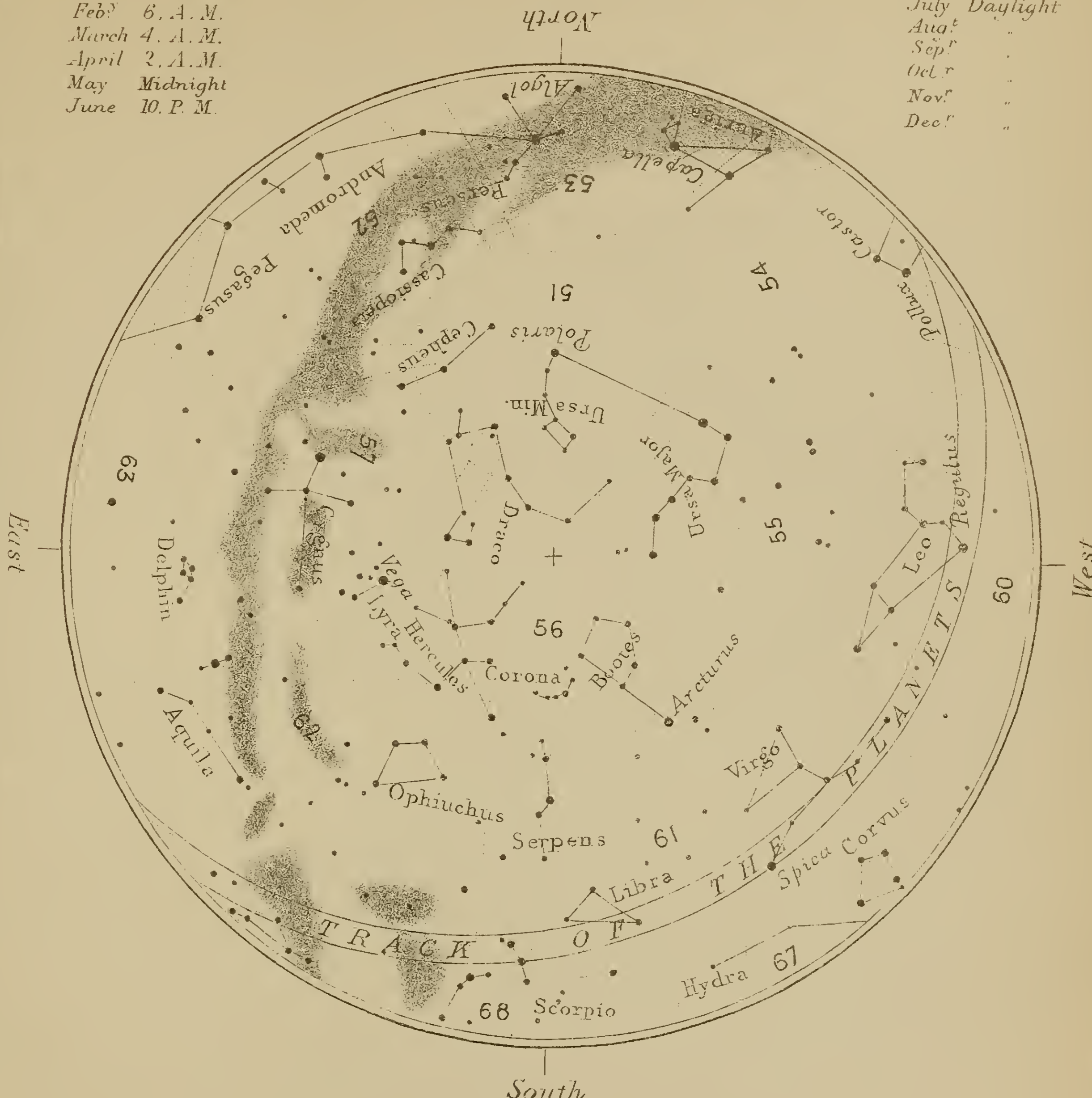
1 2 3 4

May Midnight

and also as follows

Jan.y	*8. A. M.*
Feb.y	*6. A. M.*
March	*4. A. M.*
April	*2. A. M.*
May	*Midnight*
June	*10. P. M.*

July	*Daylight*
Aug.t	"
Sep.r	"
Oct.r	"
Nov.r	"
Dec.r	"



or at Sidereal Time $15^h\ 37^m$

1 2 3 4

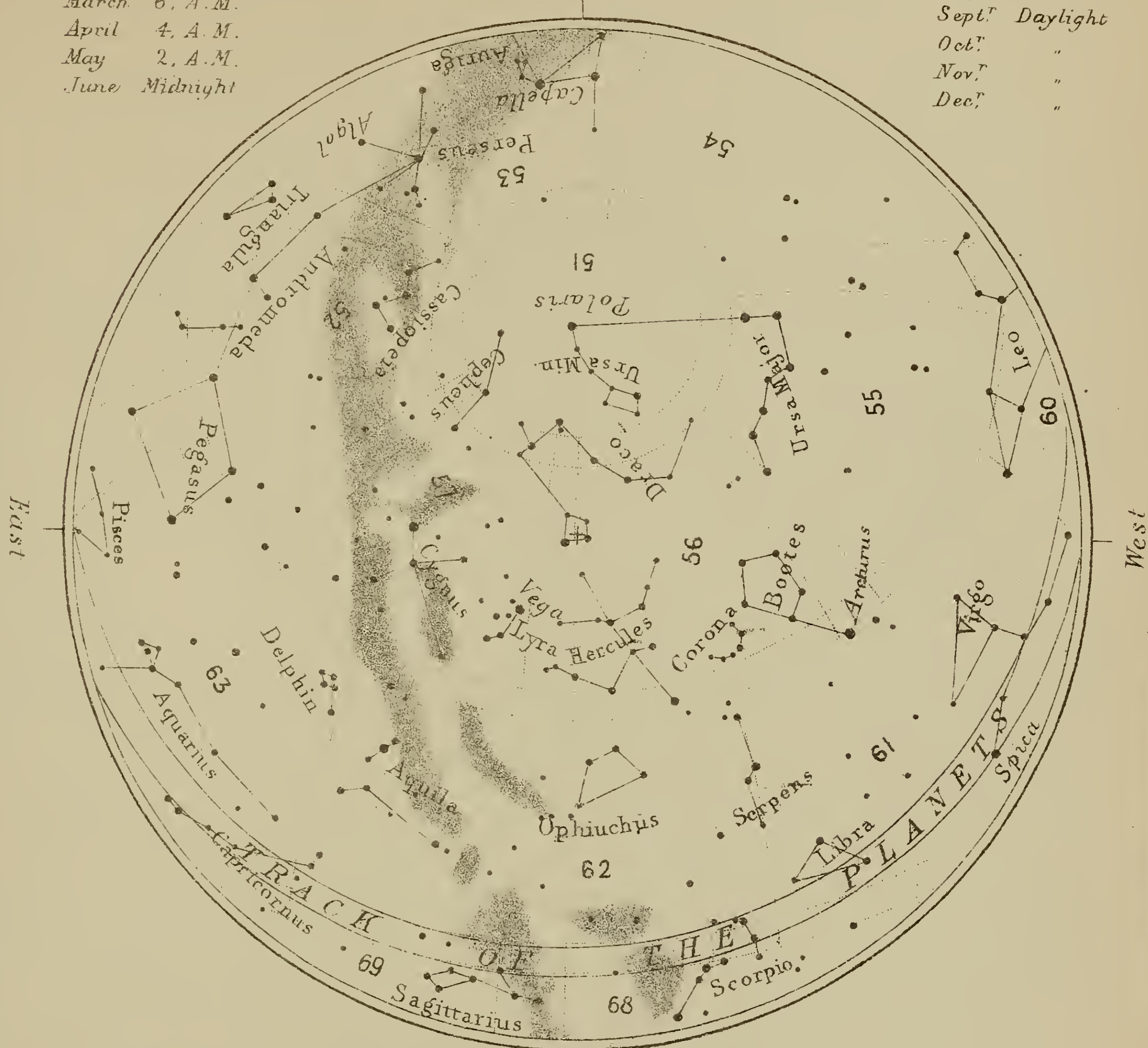
June Midnight

and also as follows

Jan.y	Daylight
Feb.y	"
March	6, A.M.
April	4, A.M.
May	2, A.M.
June	Midnight

July	10, P.M.
Aug.t	8, P.M.
Sept.r	Daylight
Oct.r	"
Nov.r	"
Dec.r	"

North



South

or at Sidereal Time 17h 37m

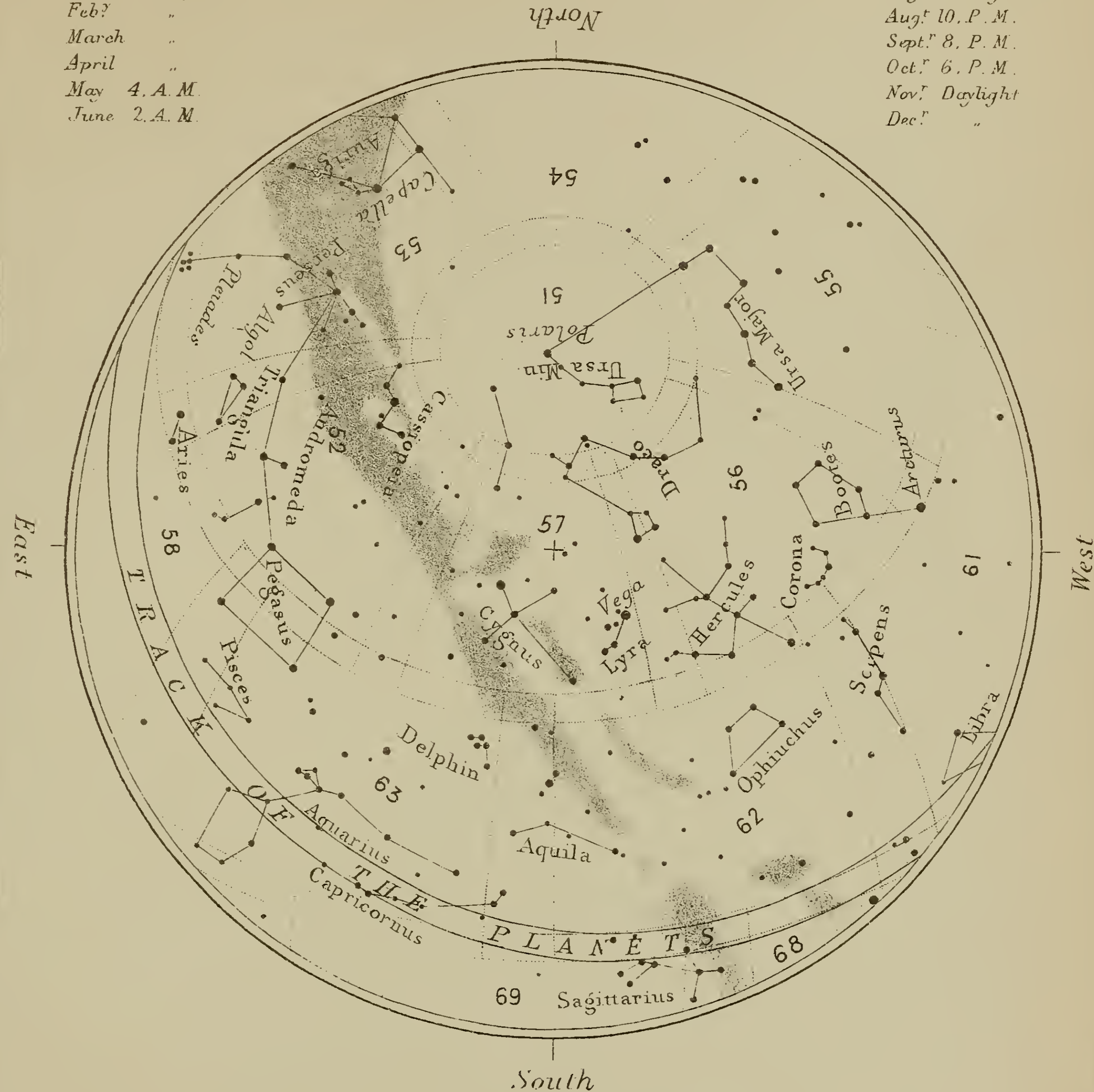
1 2 3 4

July Midnight

and also as follows

Jan.y Daylight	
Feb.y	"
March	"
April	"
May	4. A. M.
June	2. A. M.

July Midnight	
Aug.t	10. P. M.
Sept.r	8. P. M.
Oct.r	6. P. M.
Nov.r Daylight	
Dec.r	"



or at Sidereal Time $19^h\ 37^m$

1 2 3 4

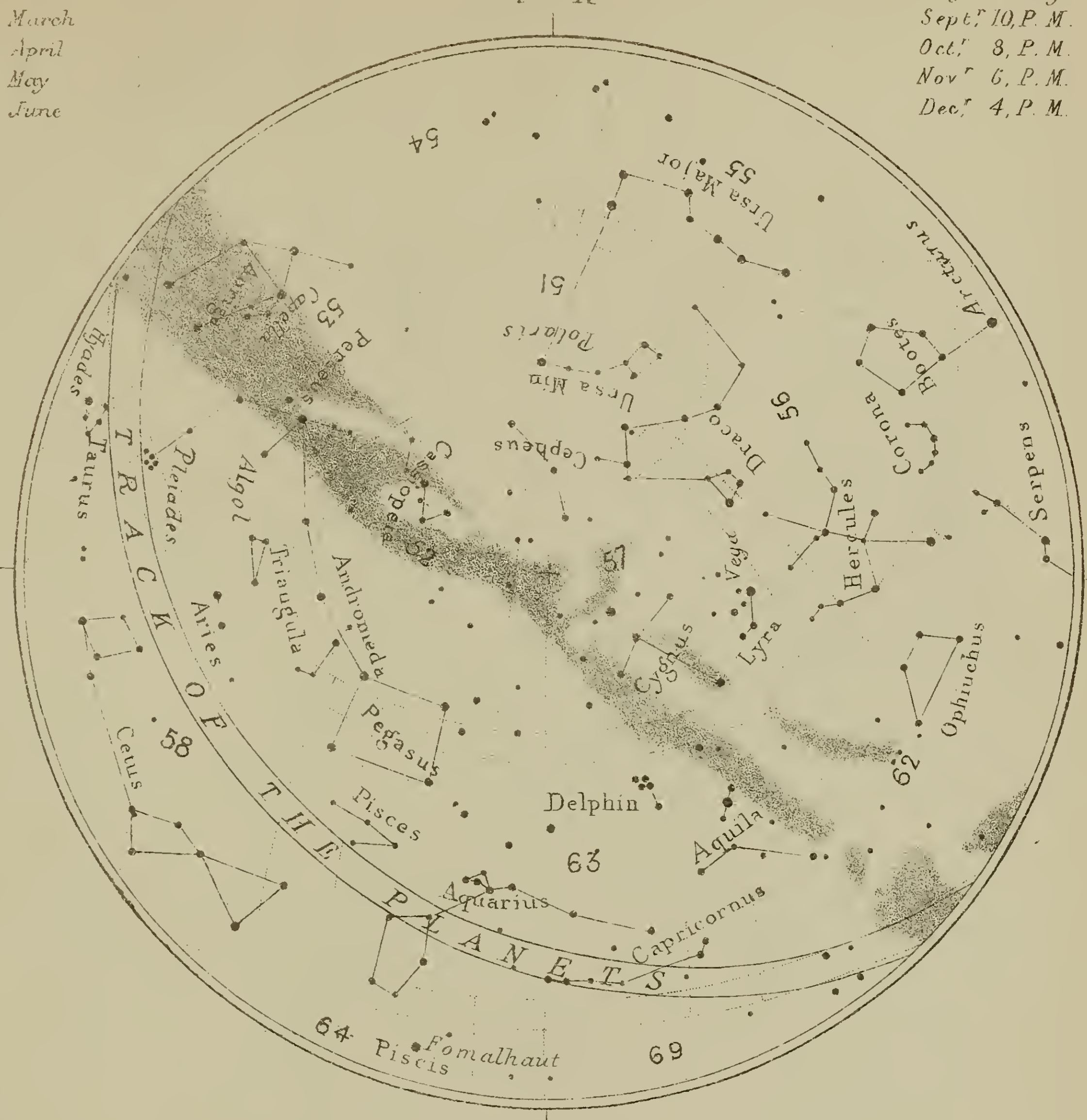
August Midnight

and also as follows

Jan. Daylight	July 2, A.M.
Feb.^y	Aug.^t Midnight
March	Sept.^r 10, P.M.
April	Oct.^r 8, P.M.
May	Nov.^r 6, P.M.
June	Dec.^r 4, P.M.

North

East



West

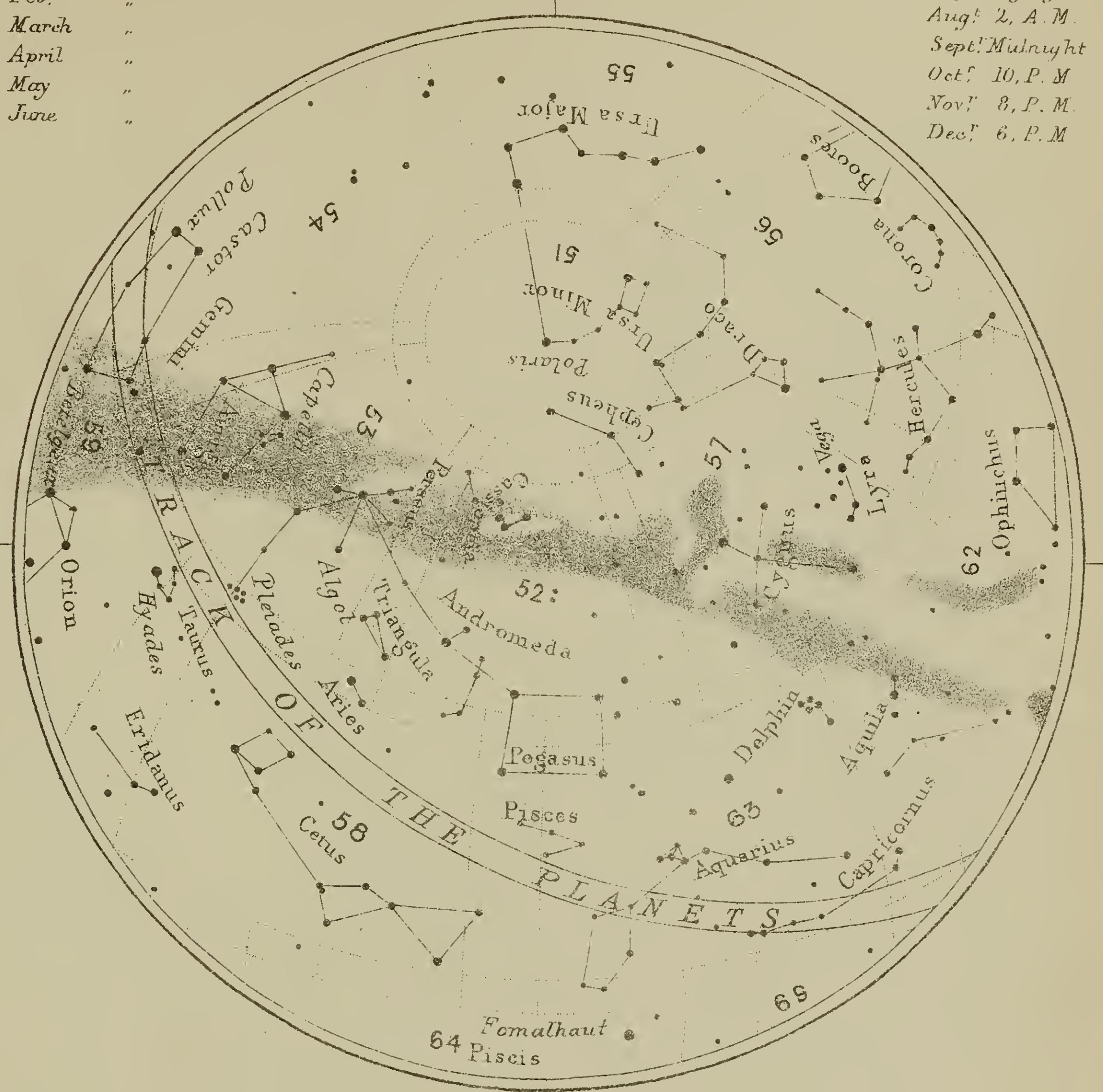
South

or at Sidereal Time $21^h\ 37^m$

1 2 3 4

September Midnight
and also as follows

Jan.y Daylight	July Daylight
Feb.y "	Aug.t 2, A. M.
March "	Sept.r Midnight
April "	Oct.r 10, P. M.
May "	Nov.r 8, P. M.
June "	Dec.r 6, P. M.



or at Sidereal Time $23^{h}\ 37^{m}$.

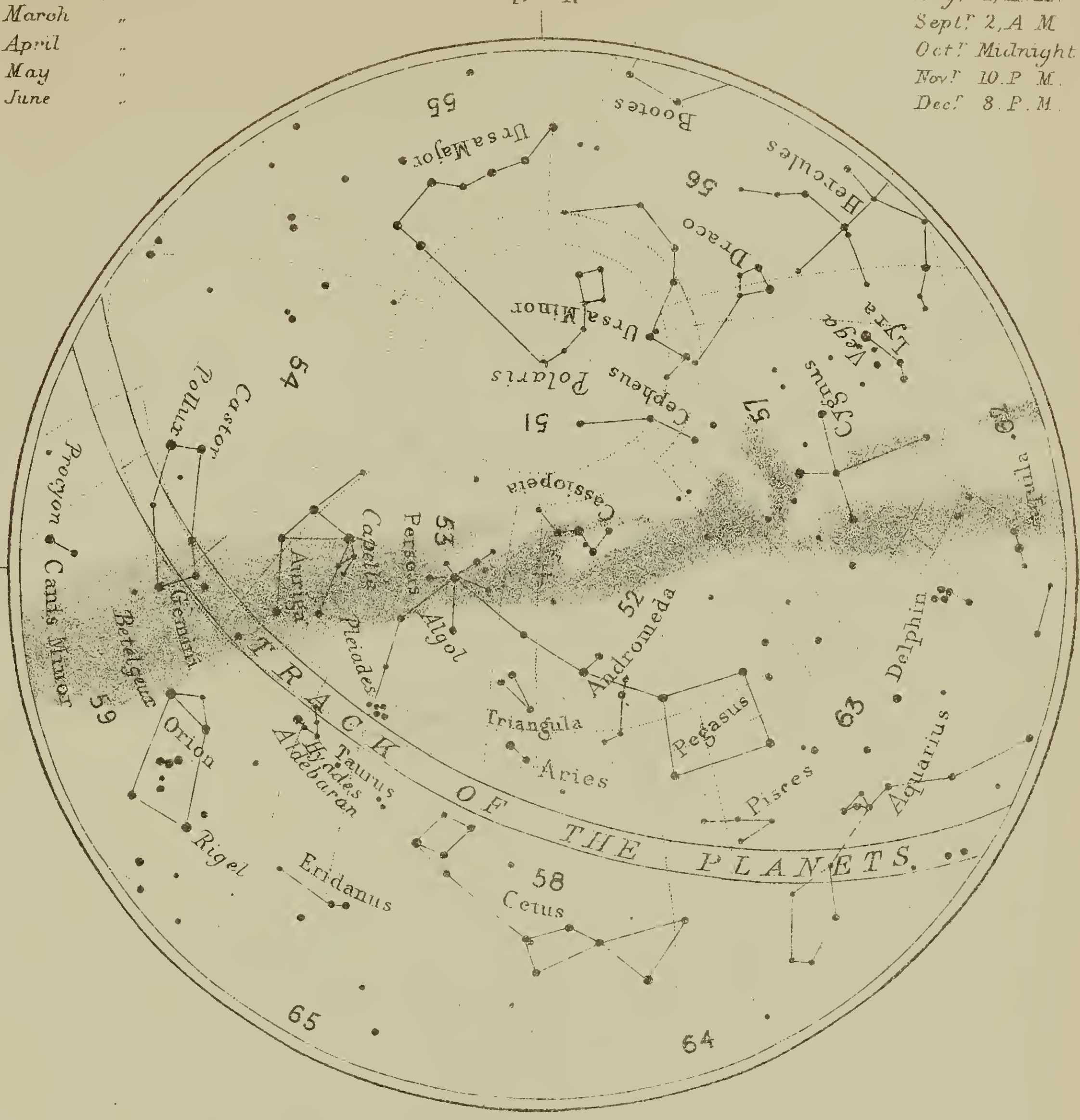
1 2 3 4

October Midnight

and also as follows

Jan.y 6, P. M.
Feb.y Daylight
March "
April "
May "
June "

July Daylight
Aug.t 4, A. M.
Sept.r 2, A. M.
Oct.r Midnight
Nov.r 10. P. M.
Dec.r 8. P. M.



South

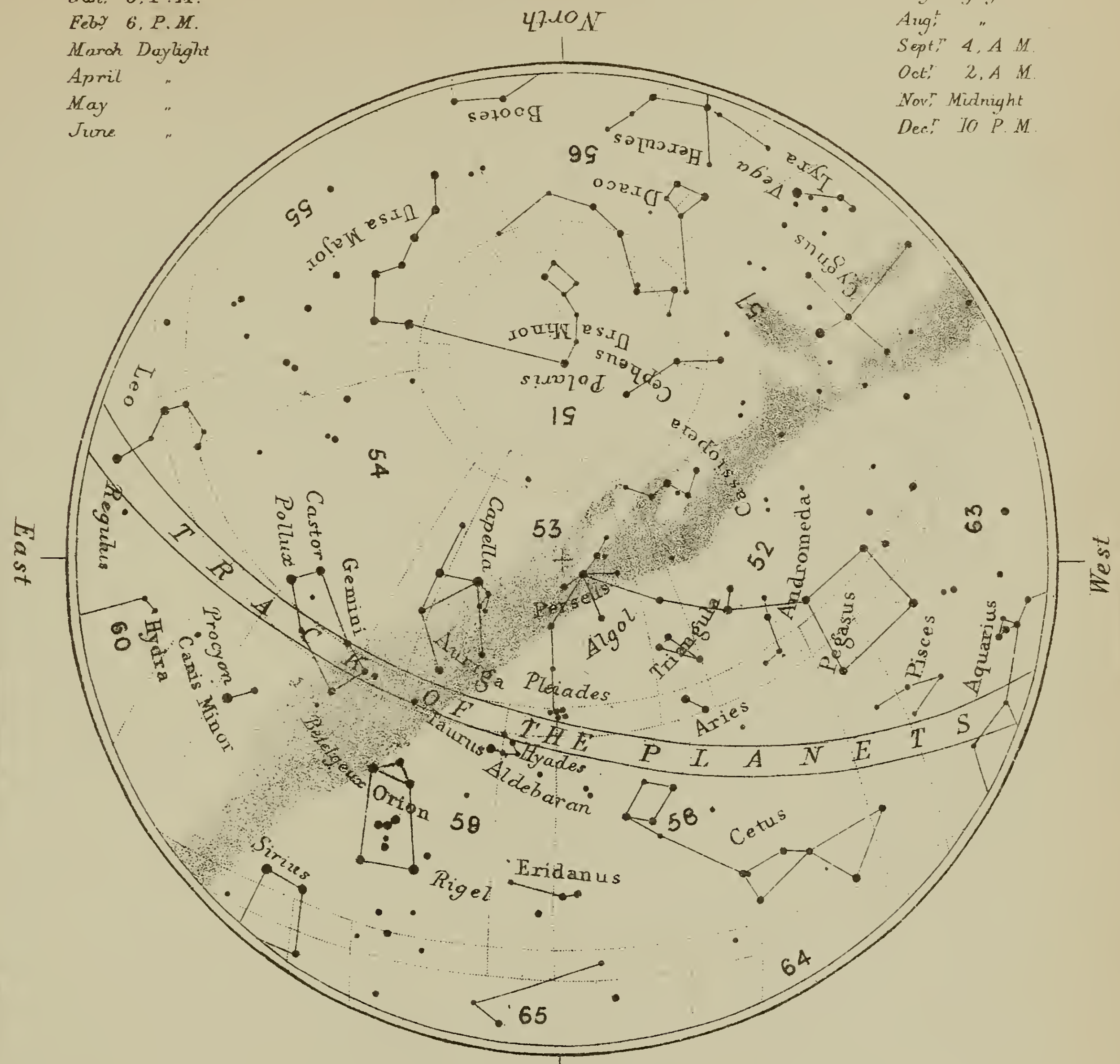
or at Sidereal Time 1^{h} 37^{m}

1 2 3 4

November Midnight

and also as follows

Jan.y 8, P.M.	*July Daylight*
Feb.y 6, P.M.	*Aug.t "*
March Daylight	*Sept.r 4, A.M.*
April "	*Oct.r 2, A.M.*
May "	*Nov.r Midnight*
June "	*Dec.r 10 P.M.*



South

or at Sidereal Time $3^{h}\ 37^{m}$.

1 2 3 4

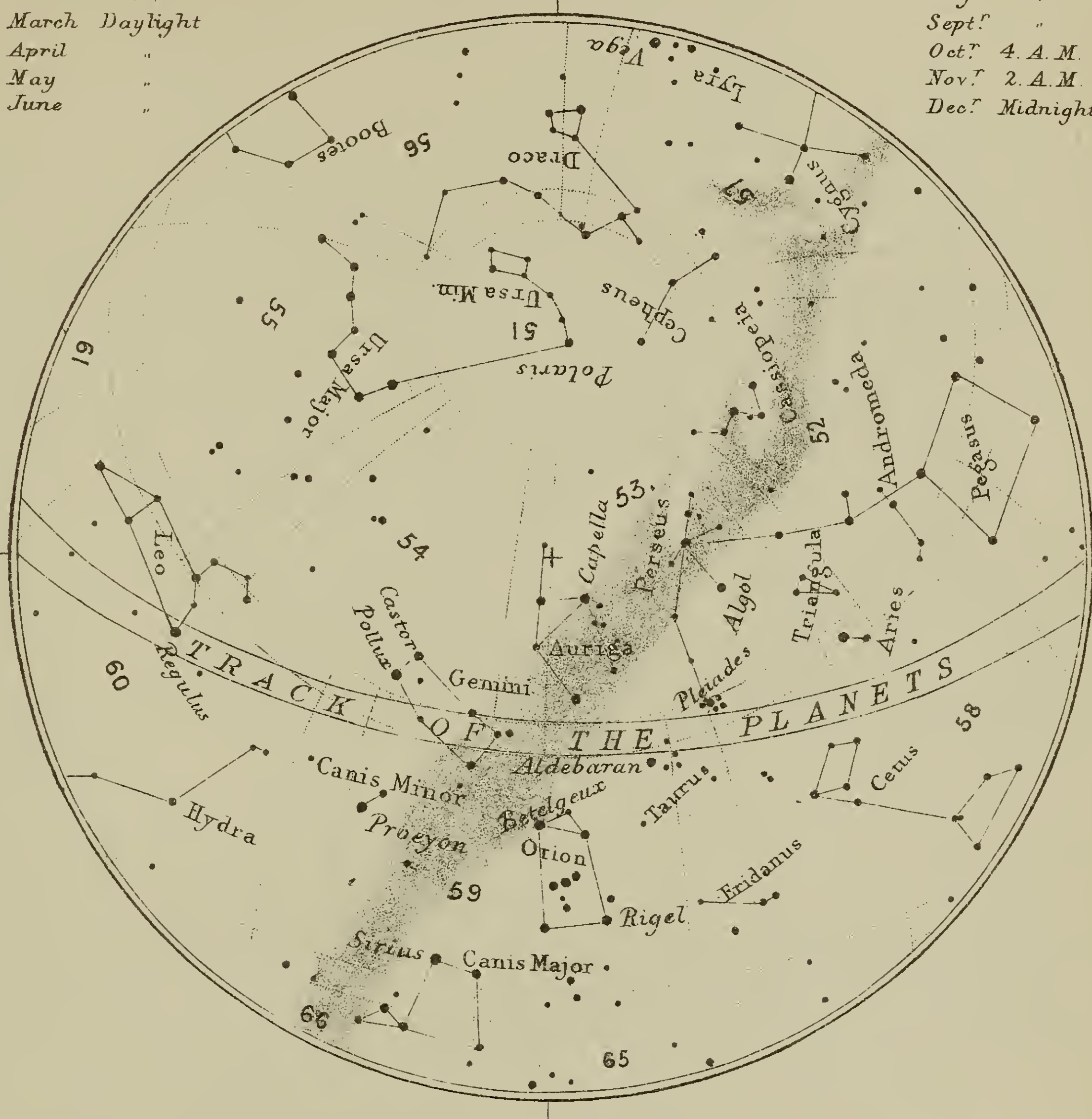
December Midnight

and also as follows

Jan.y 10. P.M.		*July Daylight*	
Feb.y 8. P.M.		*Aug.t*	*„*
March Daylight		*Sept.r*	*„*
April	*„*	*Oct.r 4. A.M.*	
May	*„*	*Nov.r 2. A.M.*	
June	*„*	*Dec.r Midnight*	

North

East *West*

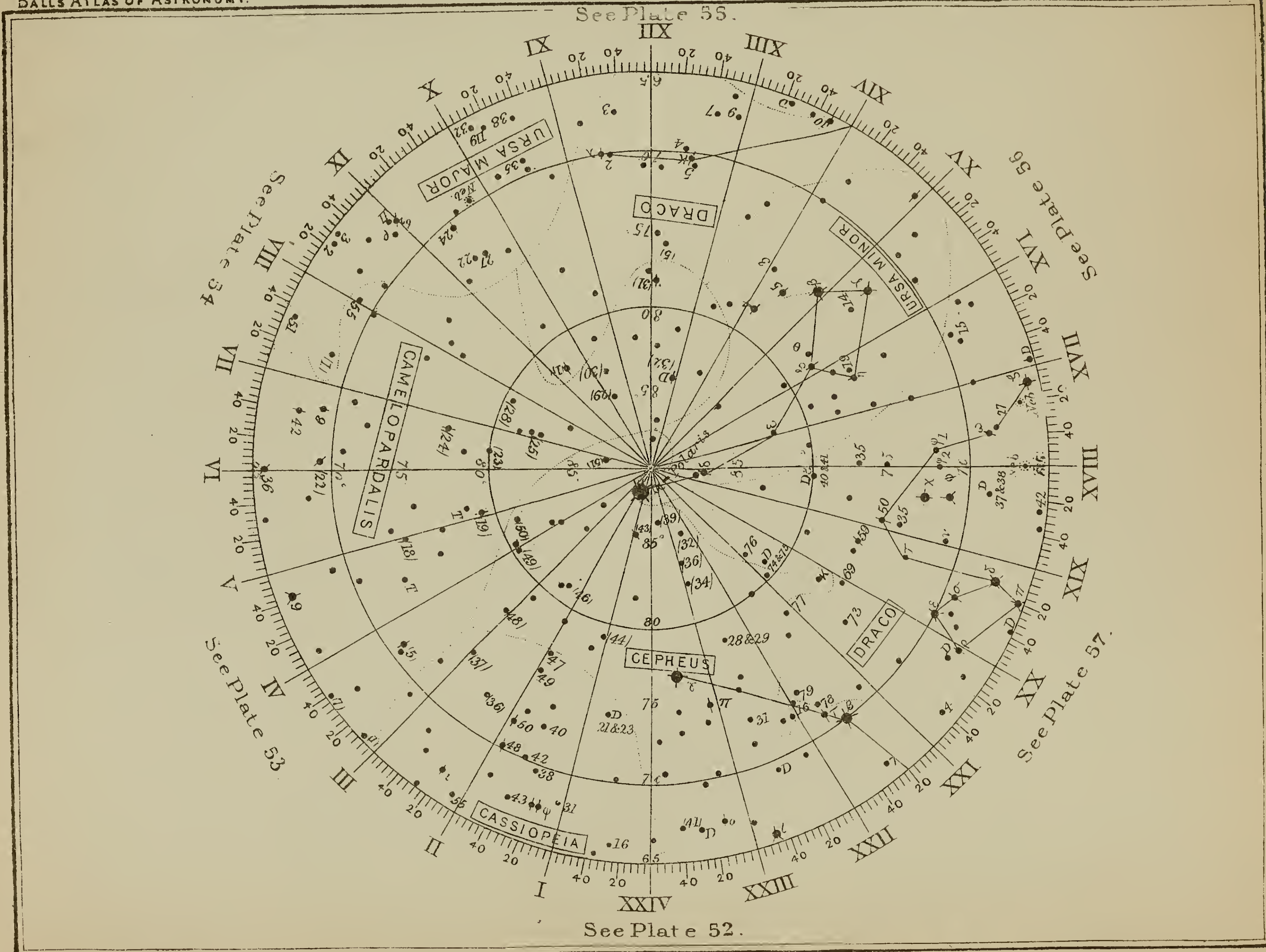


South

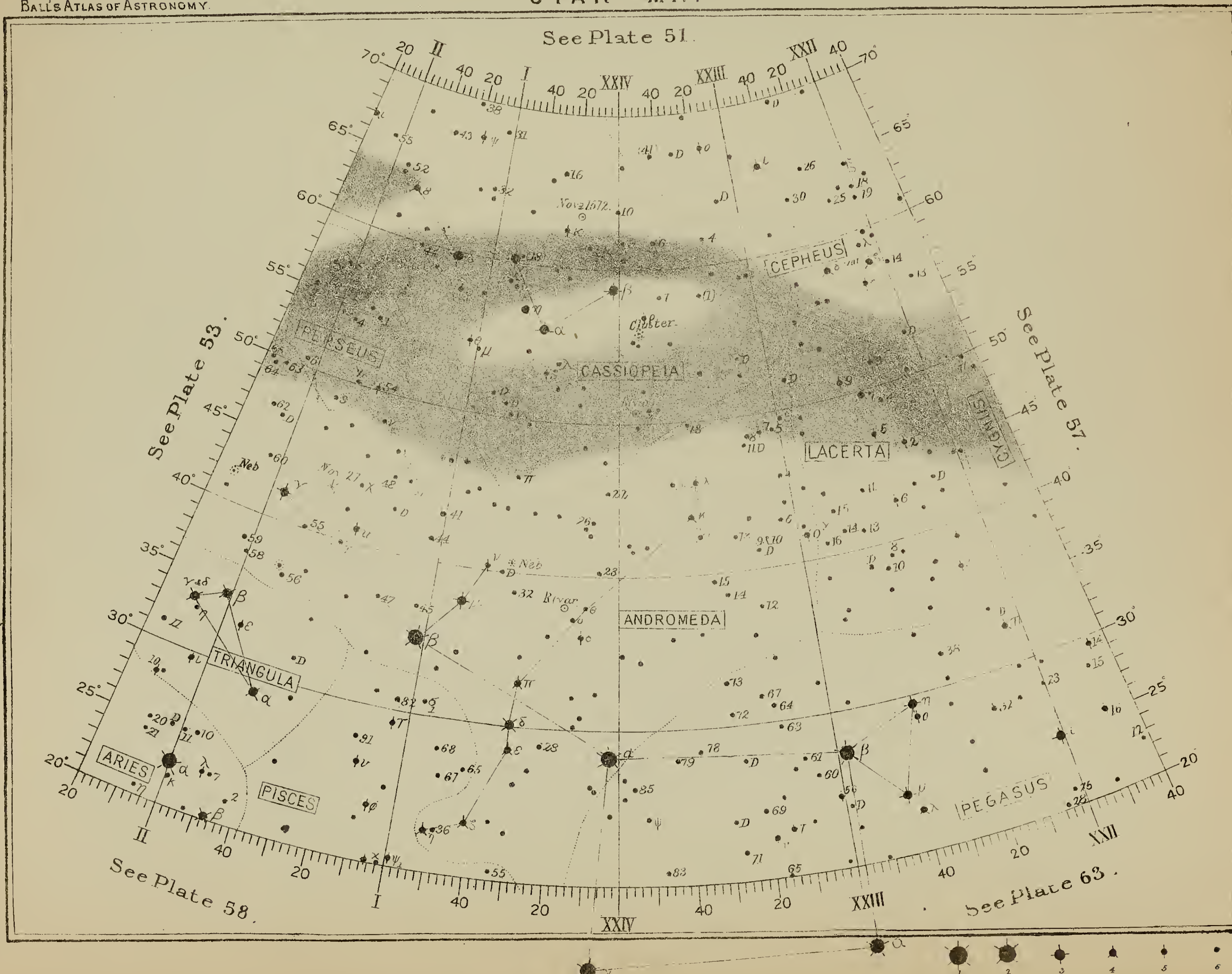
or at Sidereal Time 5^h 37^m

1 2 3 4

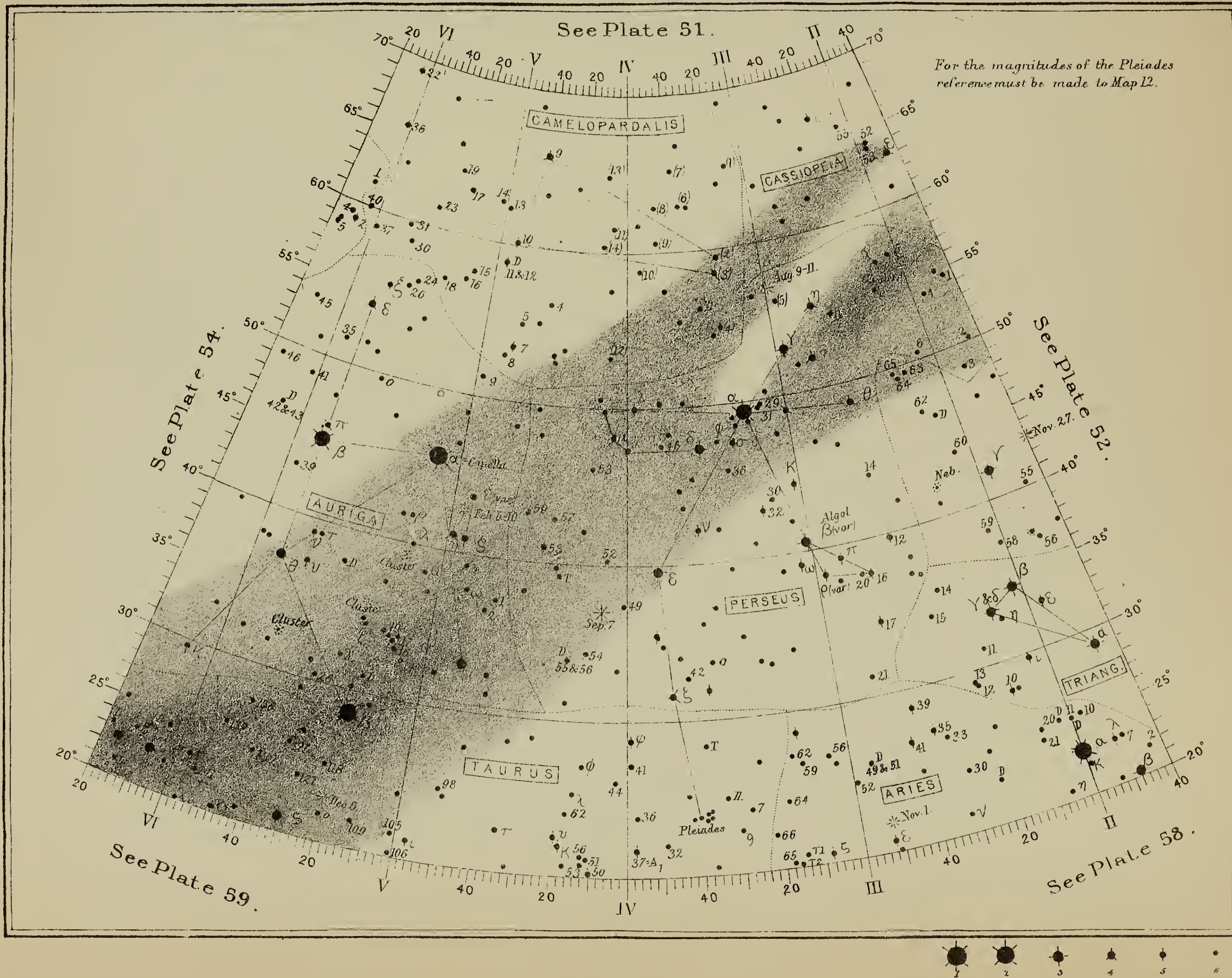
STAR MAP


See Plate 55.
See Plate 56
See Plate 57.
See Plate 52.
See Plate 53
See Plate 54
URSA MAJOR
URSA MINOR
DRACO
DRACO
CAMELOPARDALIS
CEPHEUS
CASSIOPEIA
Polaris

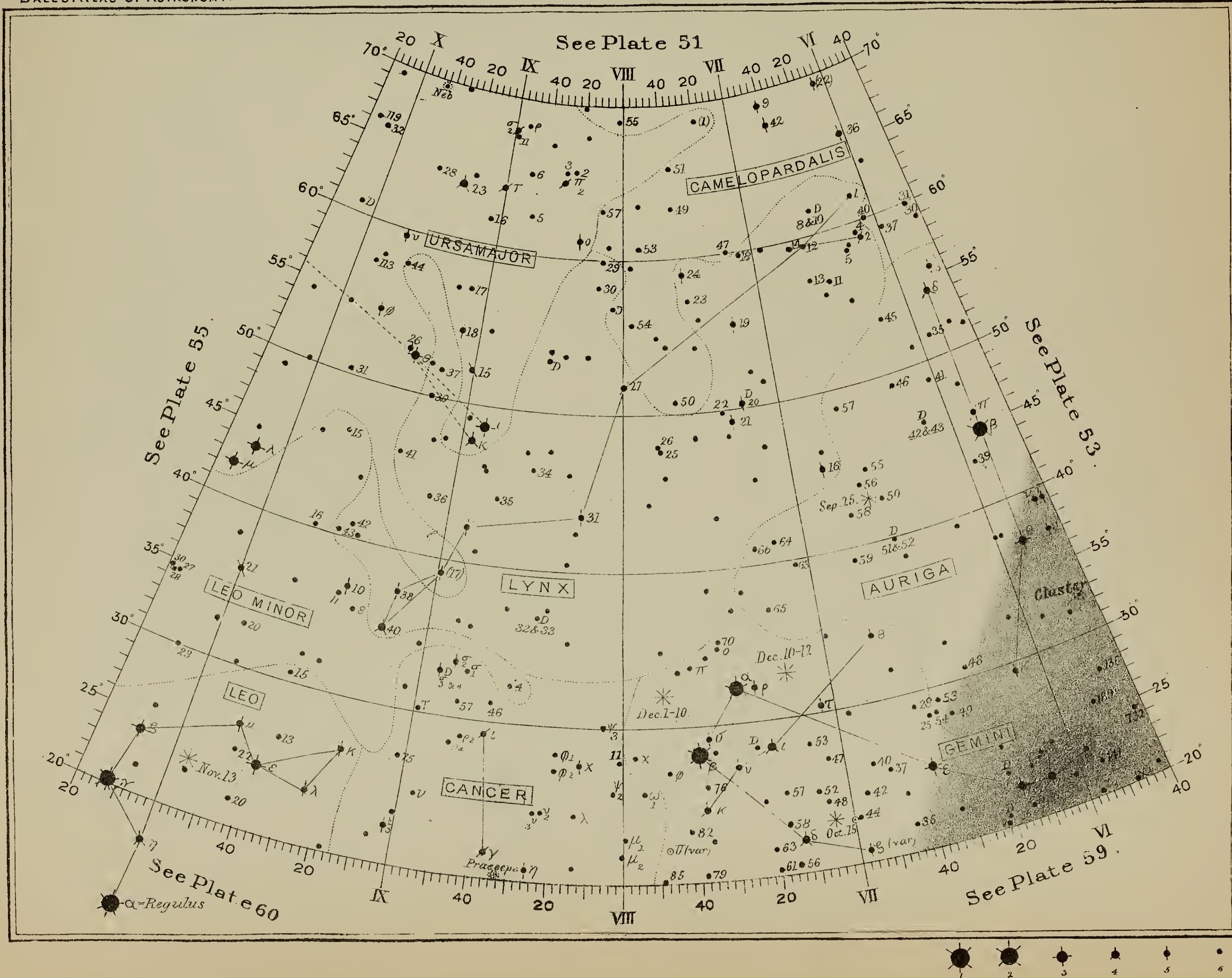
STAR MAP


See Plate 51.
See Plate 53.
See Plate 57.
See Plate 58.
See Plate 63.
CEPHEUS
PERSEUS
CASSIOPEIA
LACERTA
CYGNUS
ANDROMEDA
TRIANGULA
ARIES
PISCES
PEGASUS
Nova 1572.
Cluster.
Neb
Nebula
XXIV
XXIII
XXII
I
II

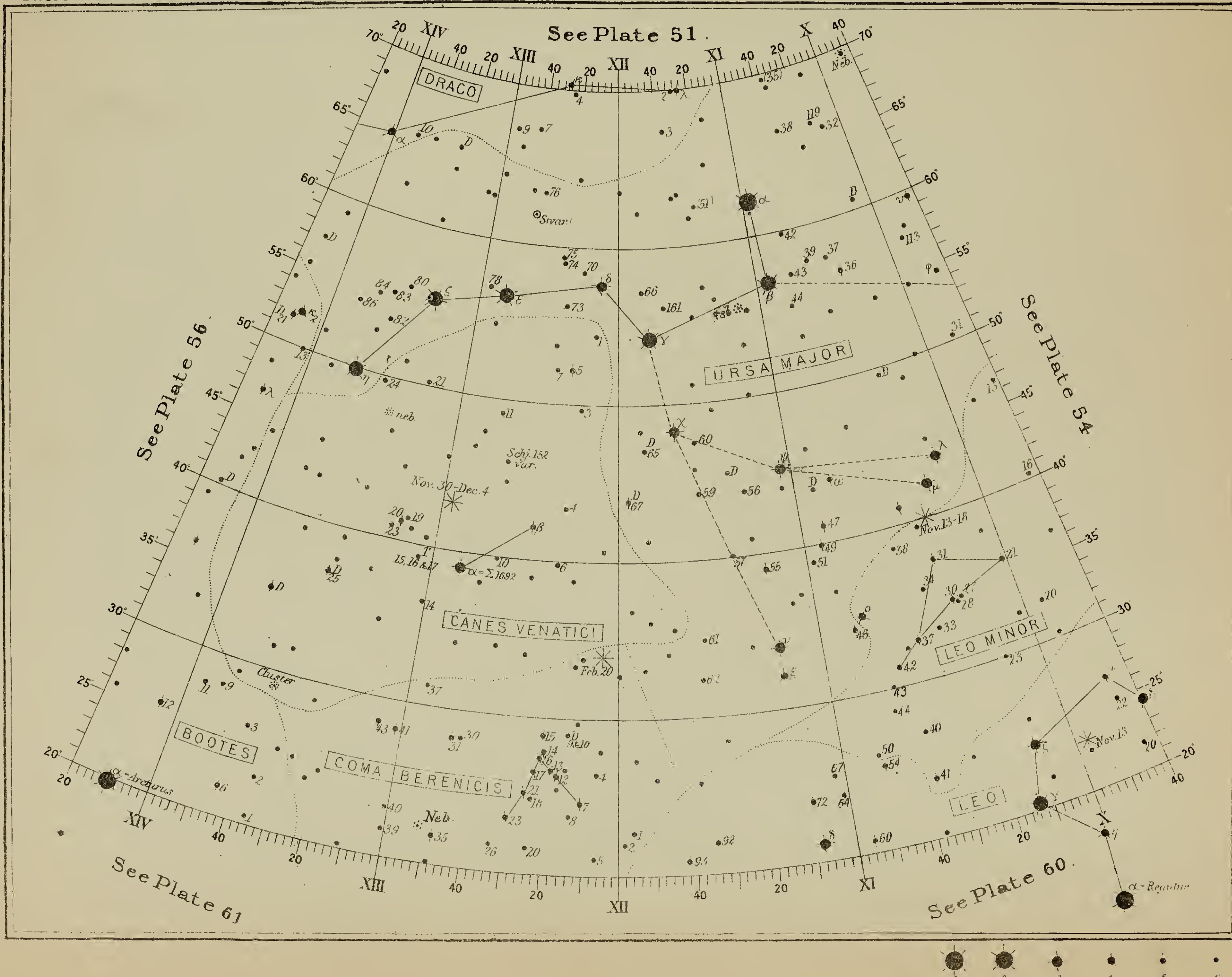
STAR MAP


See Plate 51.
See Plate 52.
See Plate 54.
See Plate 58.
See Plate 59.
For the magnitudes of the Pleiades reference must be made to Map 12.
CAMELOPARDALIS
CASSIOPEIA
AURIGA
PERSEUS
TRIANG.
TAURUS
ARIES
Capella
Algol β(var)
Pleiades
Cluster
Neb.
Aug. 9-11.
Nov. 27.
Sep. 7.
Nov. 1.
Dec. 6.

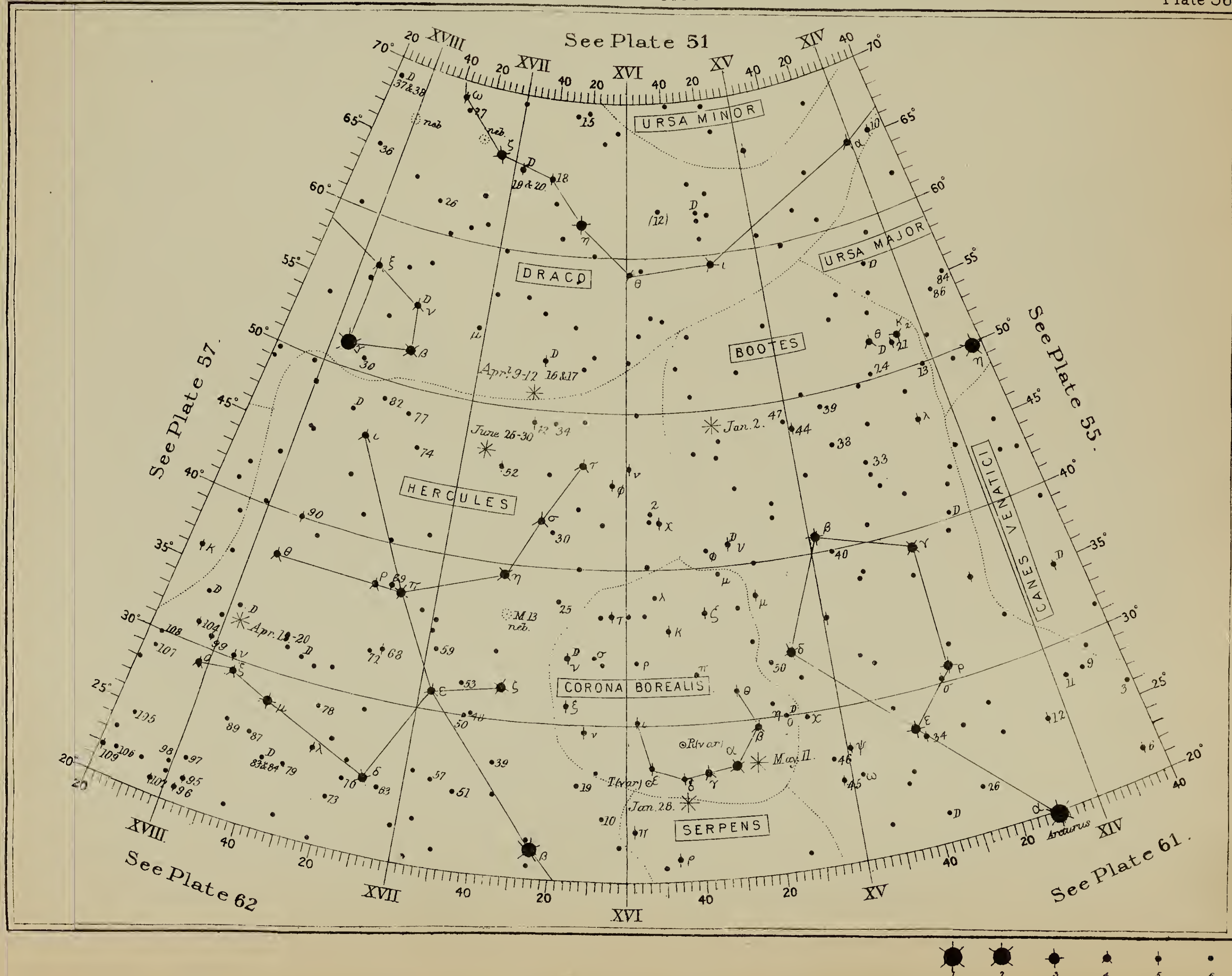
STAR MAP


See Plate 51
See Plate 53.
See Plate 59.
See Plate 60
See Plate 55.
CAMELOPARDALIS
URSA MAJOR
LYNX
LEO MINOR
LEO
CANCER
AURIGA
GEMINI
Cluster
Praesepe
α=Regulus
Dec. 10-12
Dec. 1-10
Sep. 25.
Oct. 15
Nov. 13
VI
VII
VIII
IX
X
70°
65°
60°
55°
50°
45°
40°
35°
30°
25°
20°

STAR MAP

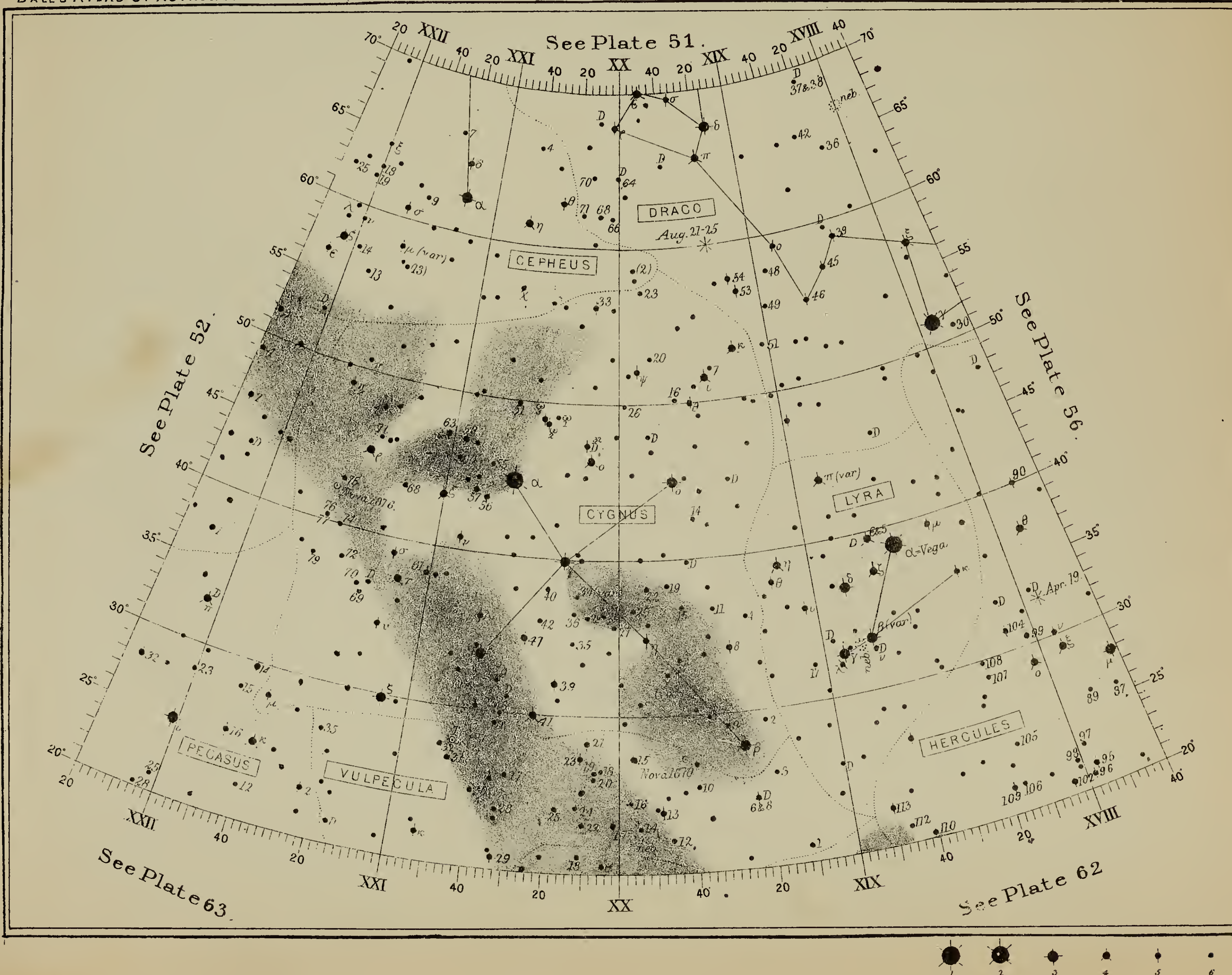

See Plate 51.
See Plate 54
See Plate 56.
See Plate 60.
See Plate 61
DRACO
URSA MAJOR
CANES VENATICI
LEO MINOR
BOOTES
COMA BERENICIS
LEO
α-Arcturus
α-Regulus
Nov. 30-Dec. 4
Nov. 13-18
Nov. 13
Feb. 20
α=Σ1692
Schj. 152 Var.
Cluster
Neb.

STAR MAP

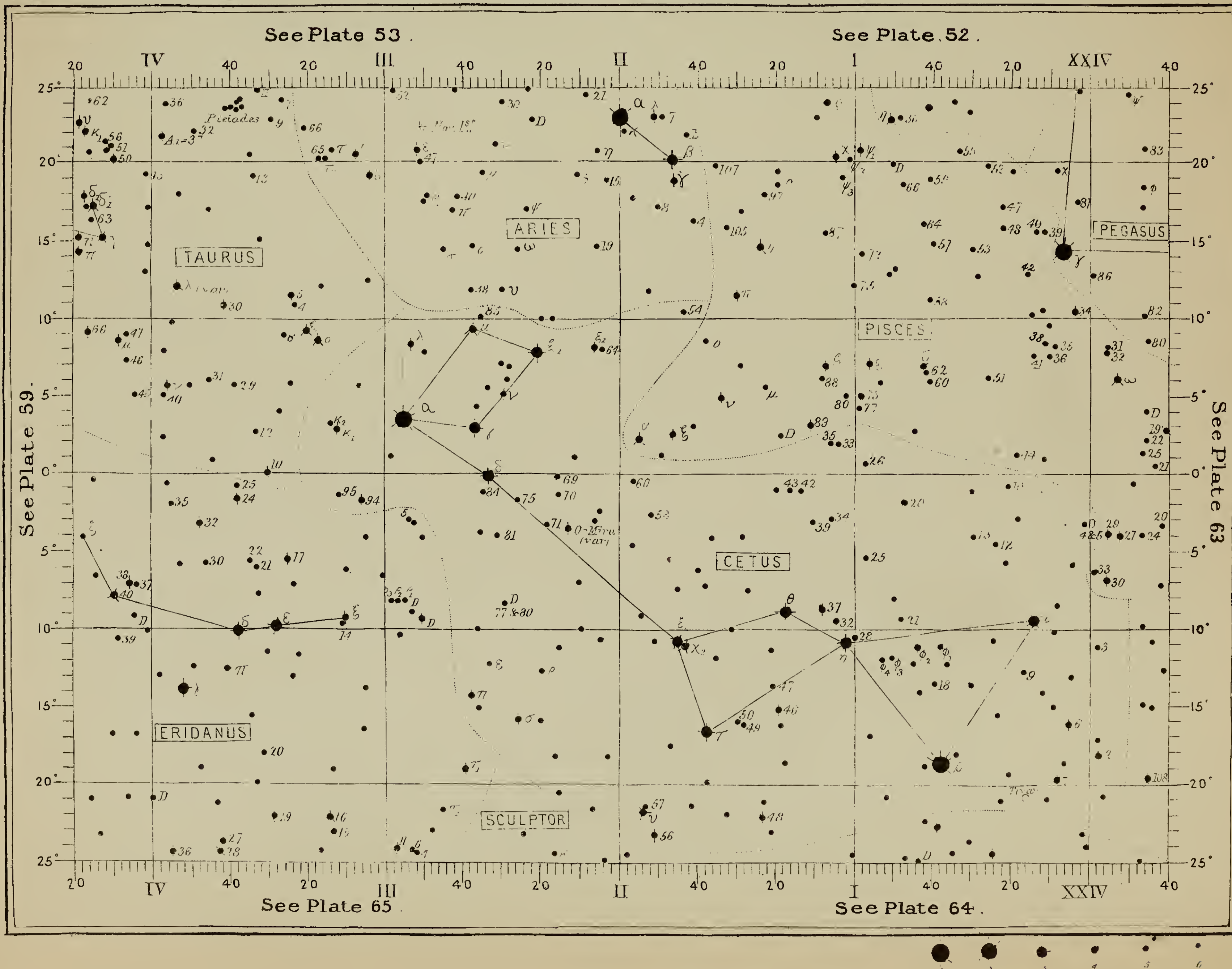


See Plate 51
See Plate 55.
See Plate 57.
See Plate 61.
See Plate 62
URSA MINOR
URSA MAJOR
DRACO
BOOTES
CANES VENATICI
HERCULES
CORONA BOREALIS
SERPENS
Arcturus
M 13 neb.
Apr. 9-12
June 26-30
Jan. 2.
Apr. 18-20
Jan. 28.
May. 11.
R (var)
T (var)
XIV
XV
XVI
XVII
XVIII

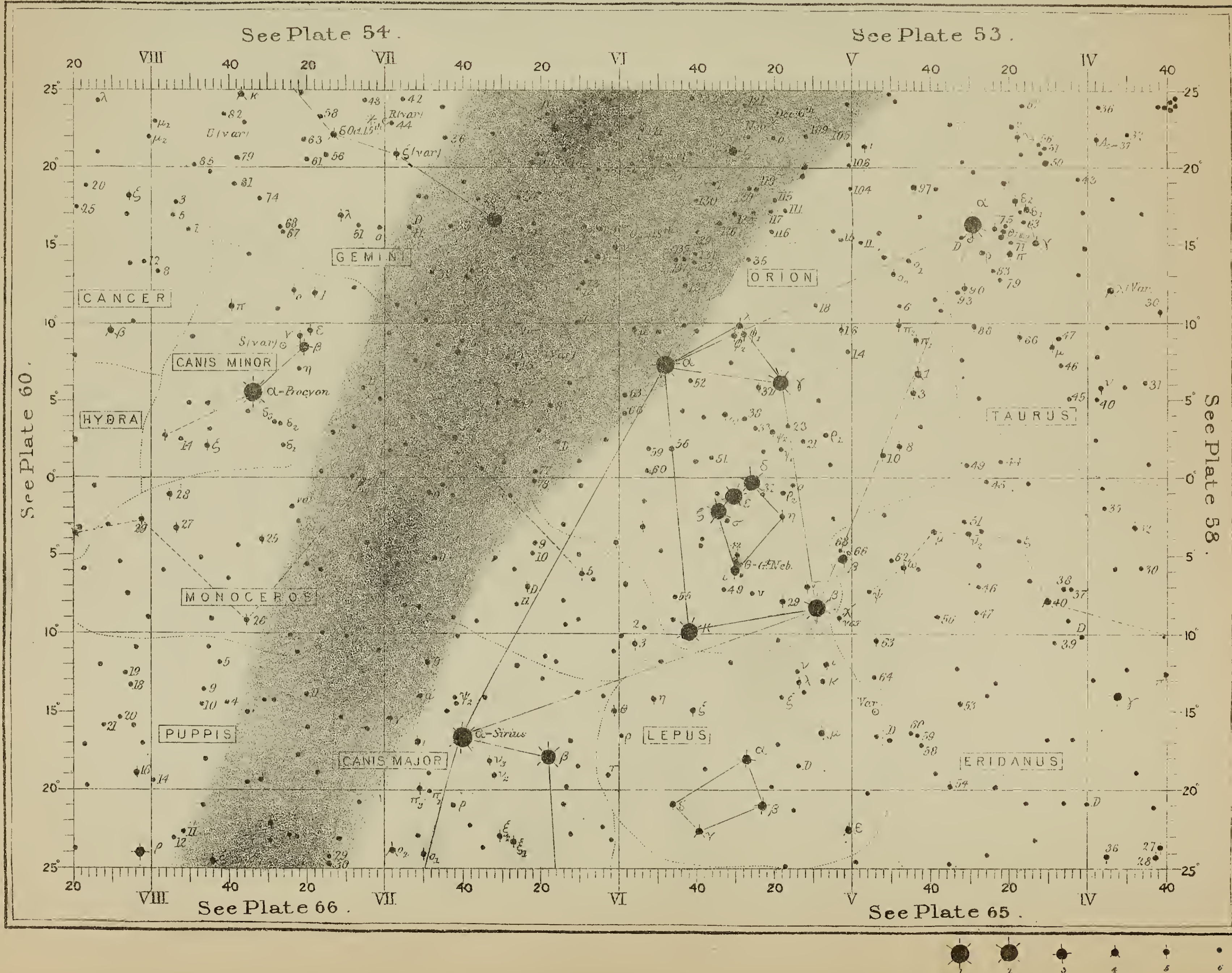
STAR MAP


See Plate 51.
See Plate 52.
See Plate 56.
See Plate 62
See Plate 63.
DRACO
CEPHEUS
CYGNUS
LYRA
HERCULES
VULPECULA
PEGASUS
α-Vega
Aug. 21-25
Apr. 19
Nova 1876.
Nova 1670
XXII
XXI
XX
XIX
XVIII

STAR MAP

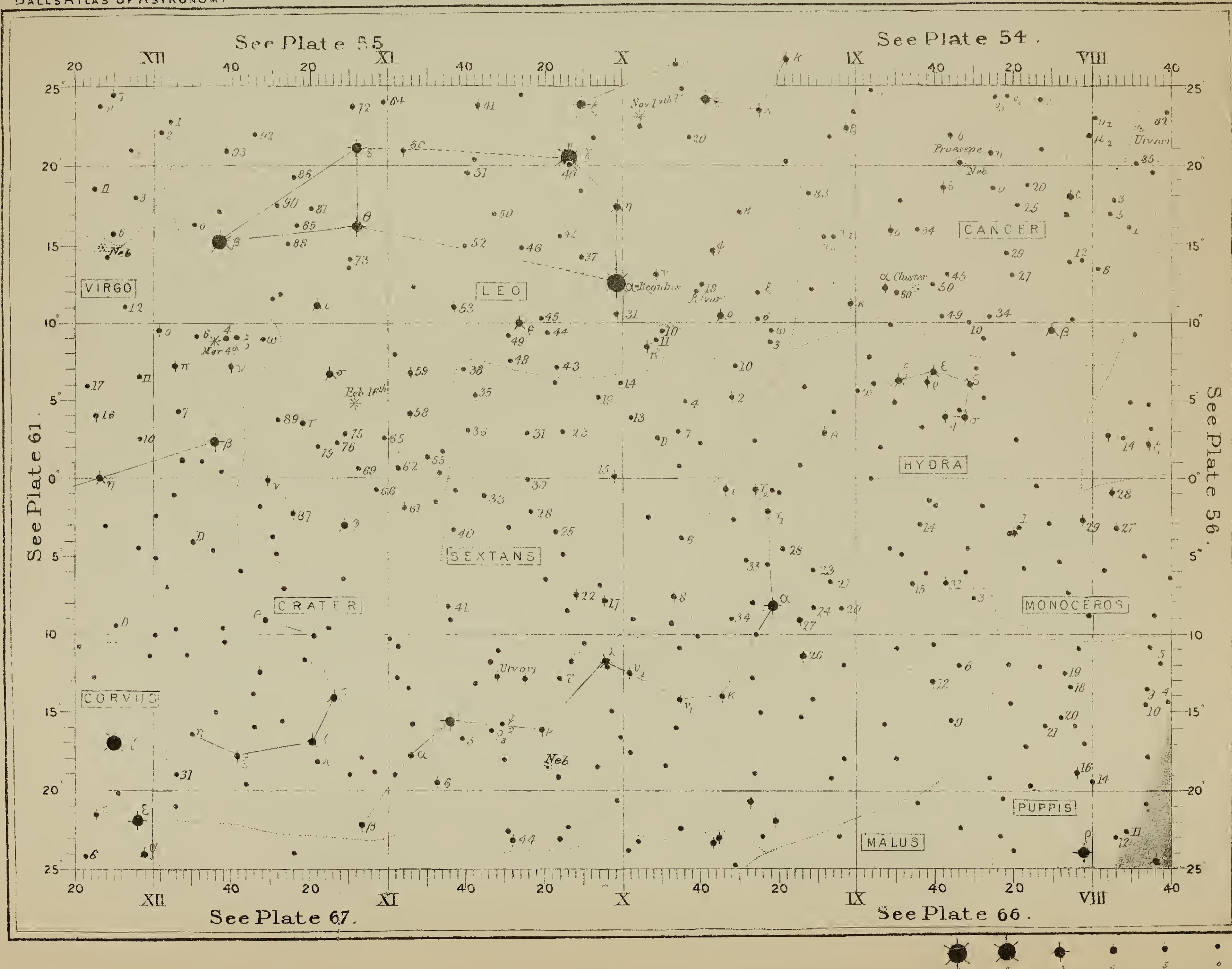

See Plate 53.
See Plate 52.
See Plate 59.
See Plate 63
See Plate 65.
See Plate 64.
TAURUS
ARIES
PEGASUS
PISCES
CETUS
ERIDANUS
SCULPTOR
Pleiades

STAR MAP

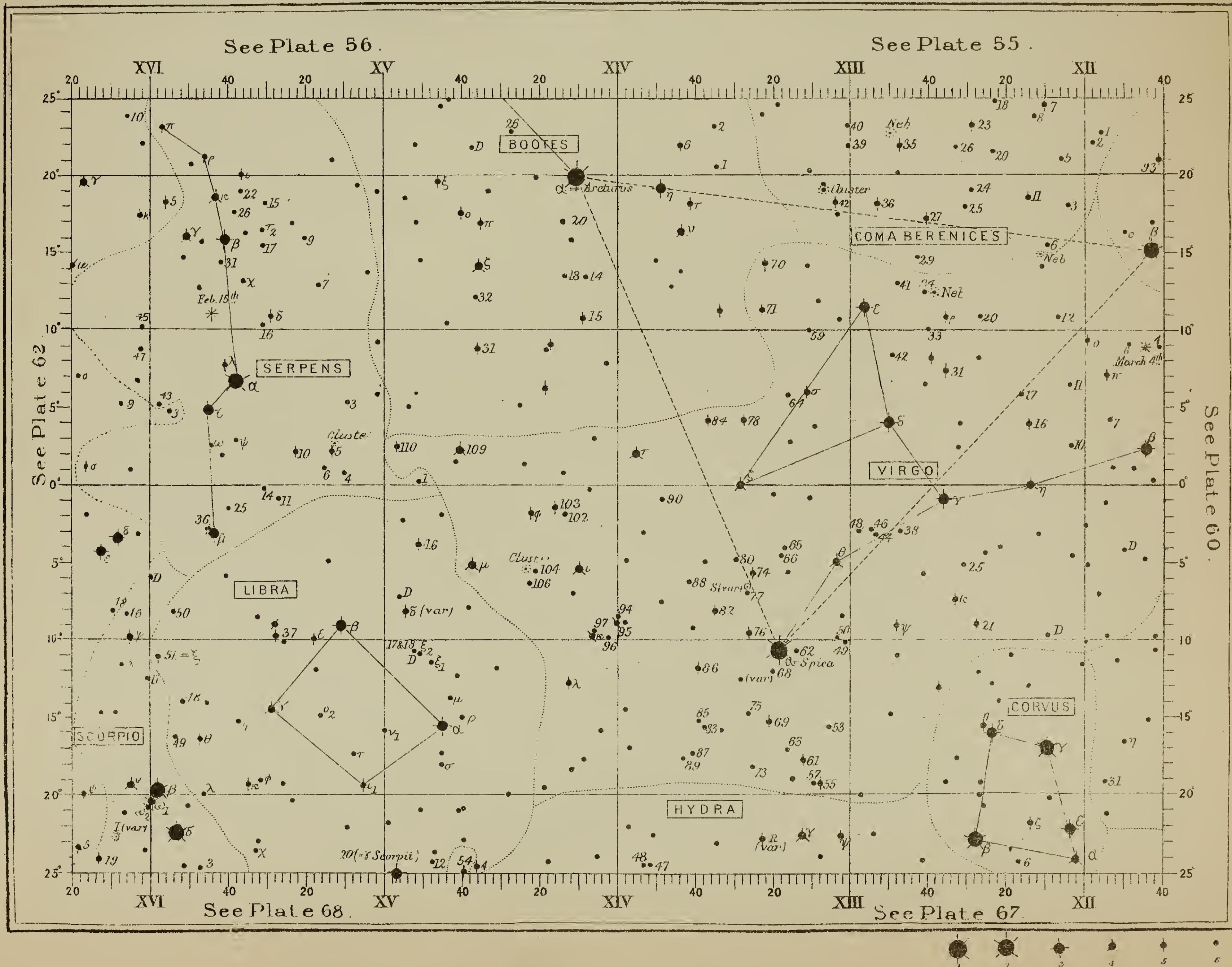


See Plate 54.
See Plate 53.
See Plate 60.
See Plate 58.
See Plate 66.
See Plate 65.
CANCER
CANIS MINOR
α-Procyon
HYDRA
GEMINI
ORION
TAURUS
MONOCEROS
PUPPIS
CANIS MAJOR
α-Sirius
LEPUS
ERIDANUS
VIII
VII
VI
V
IV

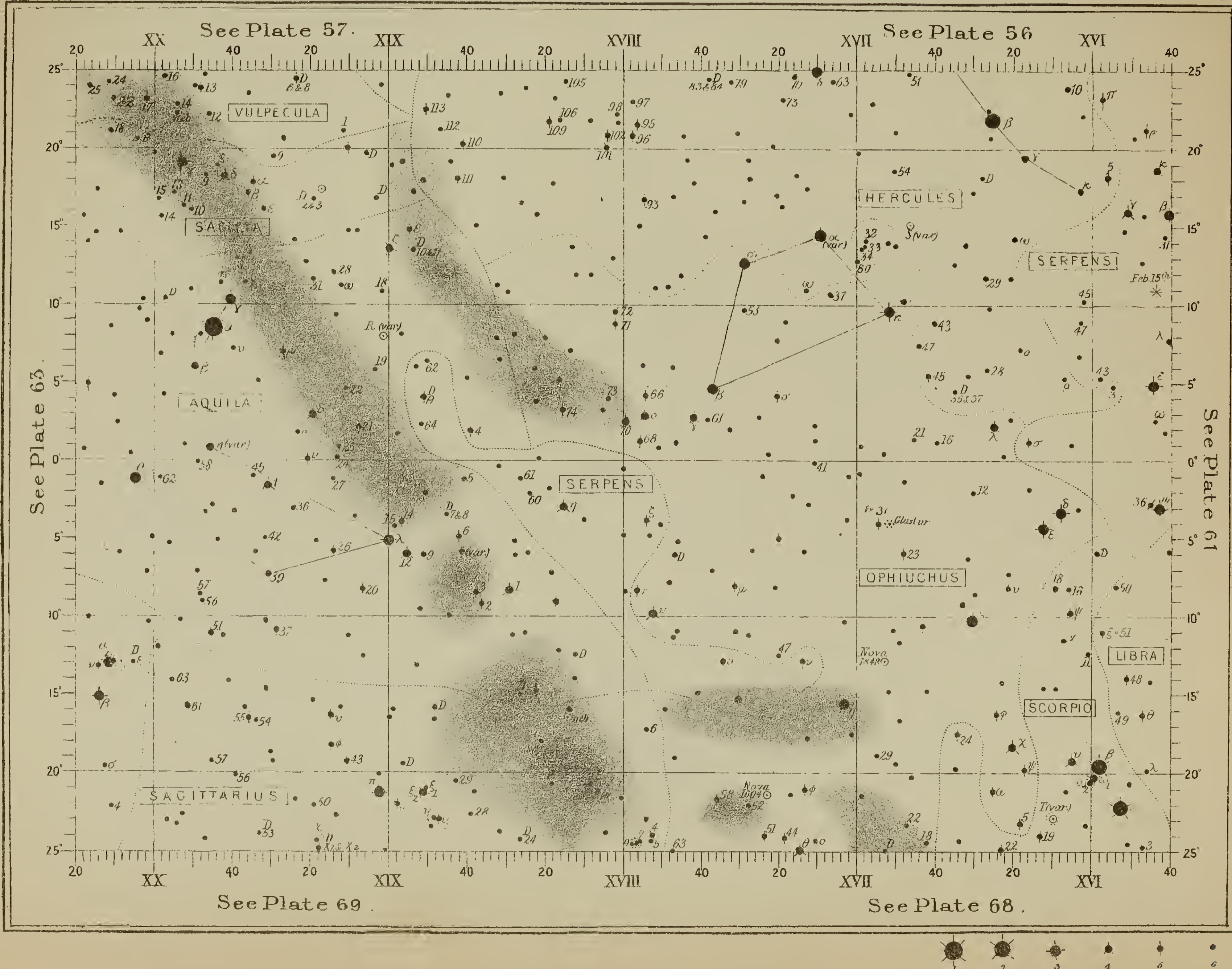
STAR MAP


See Plate 55.
See Plate 54.
See Plate 61
See Plate 56.
See Plate 67.
See Plate 66.
VIRGO
LEO
CANCER
HYDRA
SEXTANS
CRATER
CORVUS
MONOCEROS
PUPPIS
MALUS
α Regulus
Præsepe
α Cluster
Nov. 12th?
Feb 16th
Mar 4th
XII
XI
X
IX
VIII

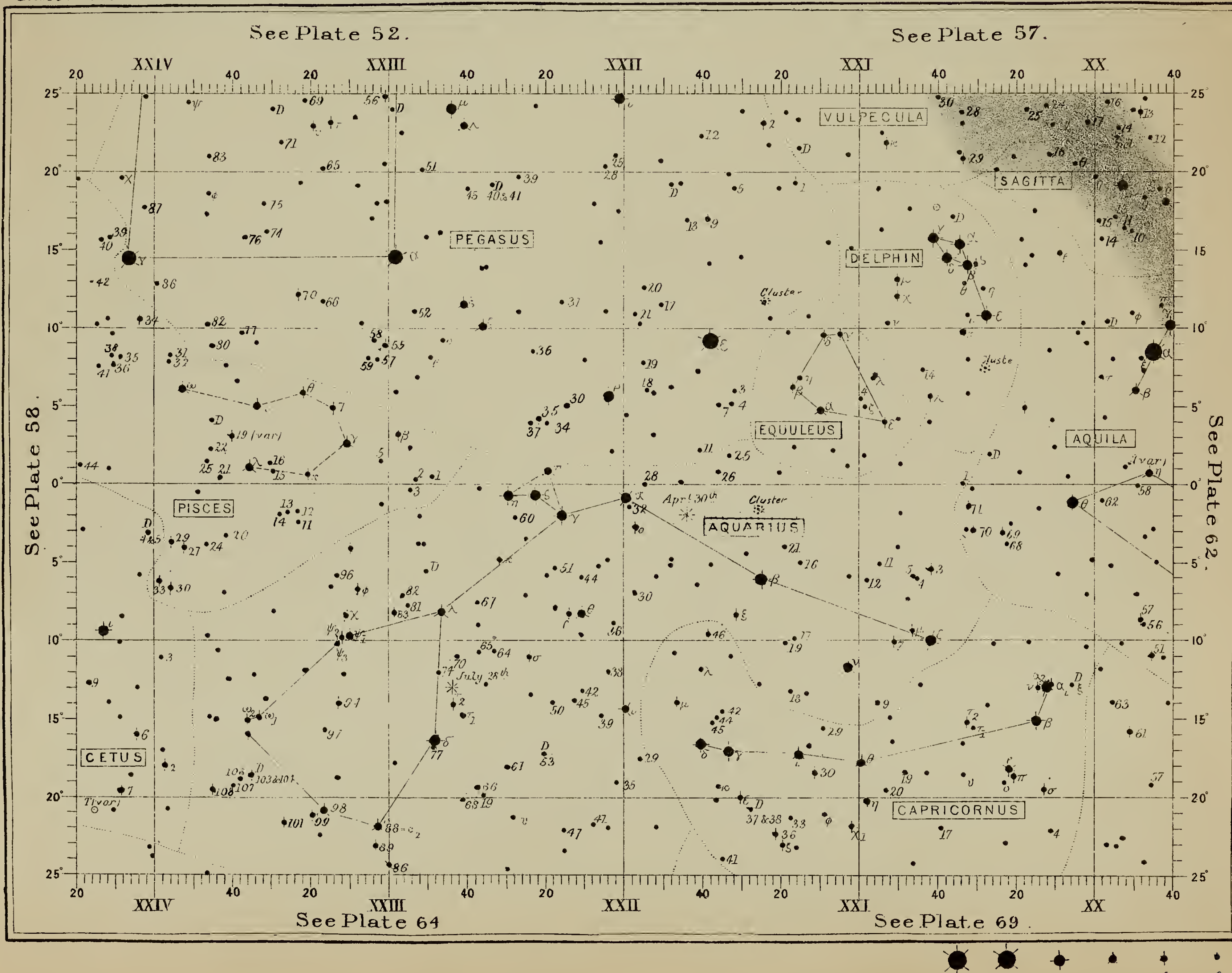
STAR MAP


See Plate 56.
See Plate 55.
See Plate 62
See Plate 60.
See Plate 68.
See Plate 67.
XVI
XV
XIV
XIII
XII
BOOTES
COMA BERENICES
SERPENS
VIRGO
LIBRA
CORVUS
HYDRA
SCORPIO
α = Arcturus
α Spica
Feb. 15th
March 4th
20 (=γ Scorpii)
Cluster
Neb
δ (var)
17&18
51 = ξ

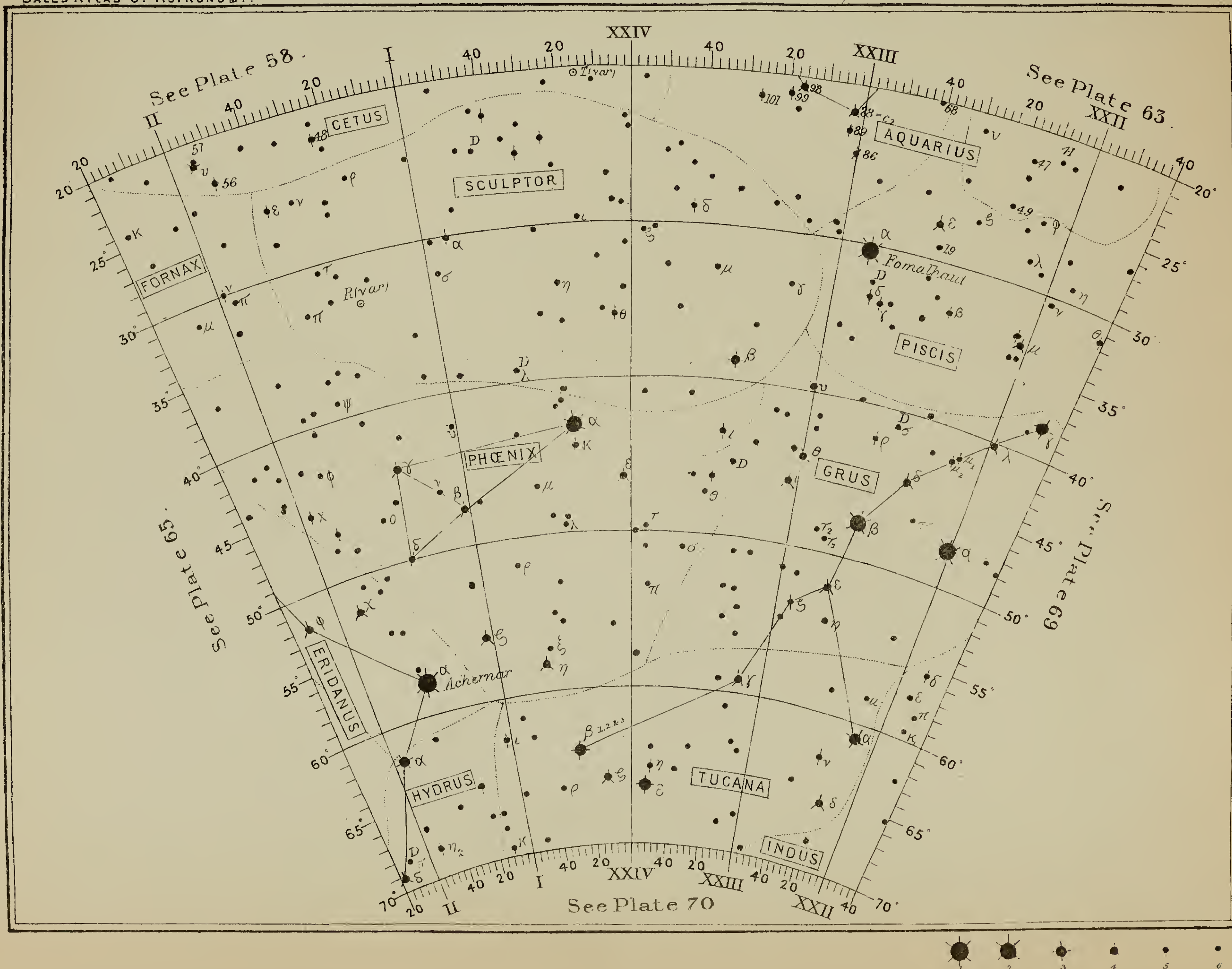
STAR MAP


See Plate 57.
See Plate 56
See Plate 61
See Plate 63
See Plate 69.
See Plate 68.
VULPECULA
SAGITTA
AQUILA
SERPENS
HERCULES
OPHIUCHUS
LIBRA
SCORPIO
SAGITTARIUS
XX
XIX
XVIII
XVII
XVI
Feb. 15th
Nova 1848
Nova 1604
R (var)
T (var)
Cluster

STAR MAP

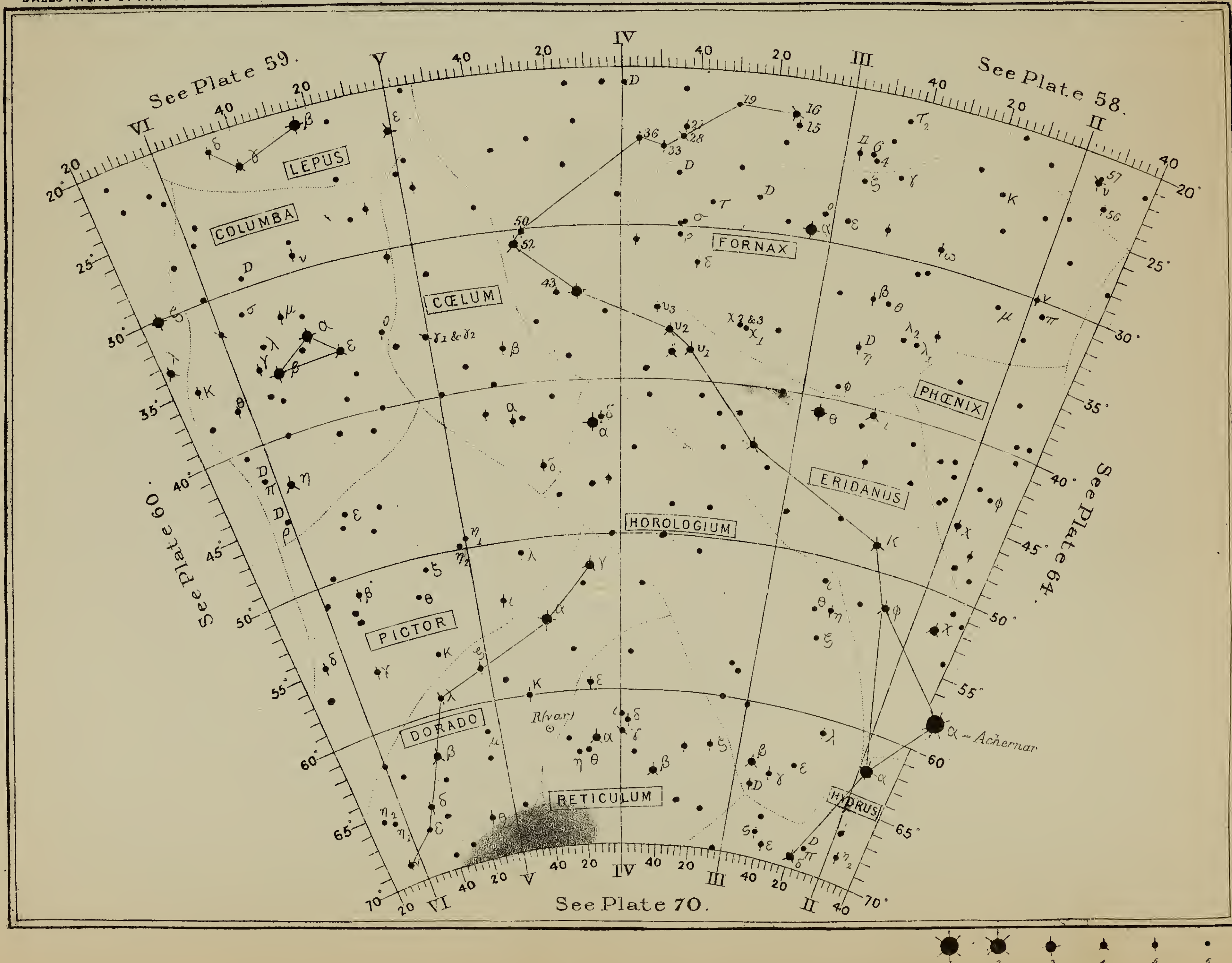

See Plate 52.
See Plate 57.
See Plate 58.
See Plate 62.
See Plate 64
See Plate 69.
VULPECULA
SAGITTA
DELPHIN
PEGASUS
EQUULEUS
AQUILA
PISCES
AQUARIUS
CETUS
CAPRICORNUS
Cluster
Apr. 30th
July 28th
19 (var.)
Tivar.
XXIV
XXIII
XXII
XXI
XX

STAR MAP.

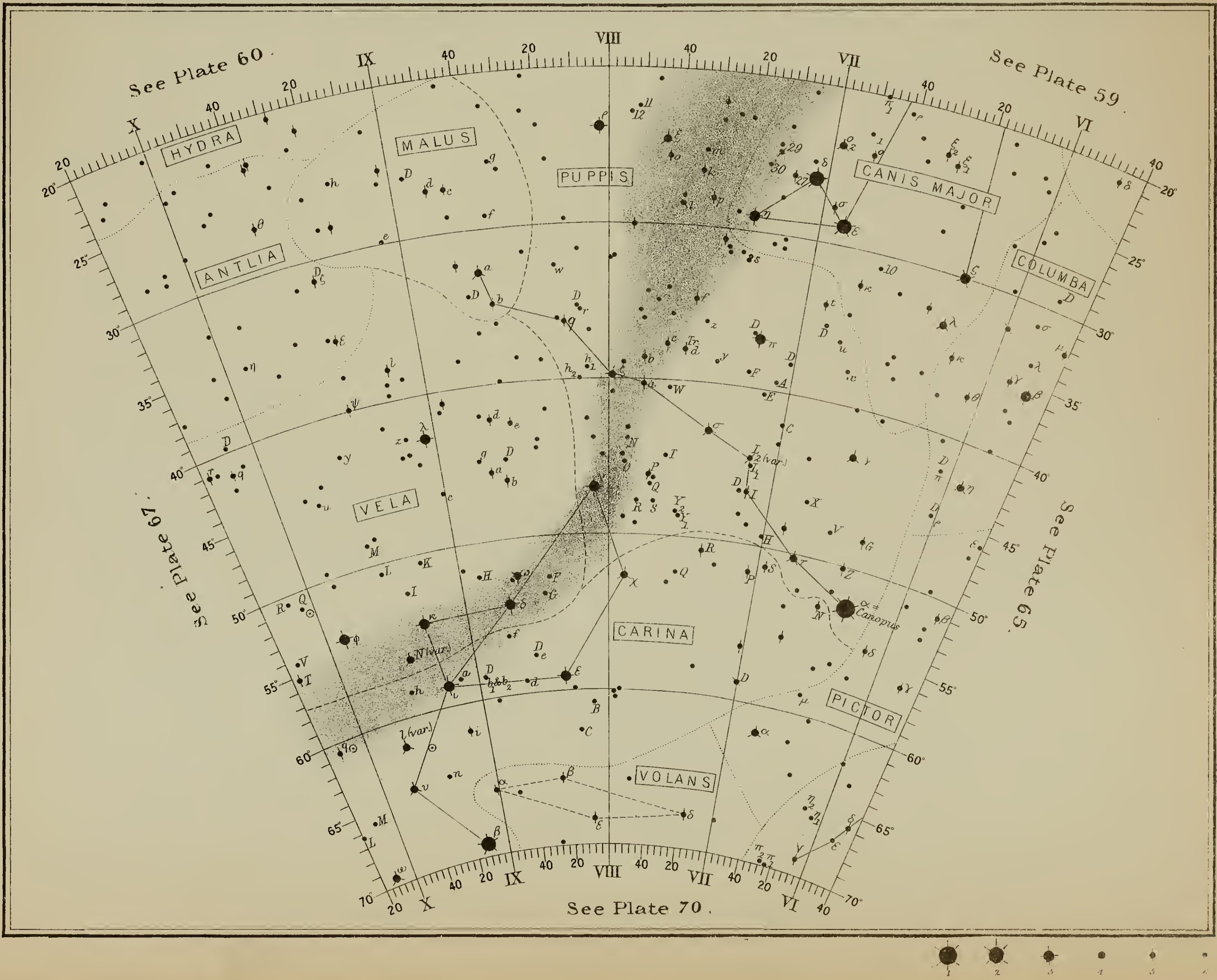


See Plate 58.
See Plate 63.
See Plate 69
See Plate 65
See Plate 70
AQUARIUS
CETUS
SCULPTOR
FORNAX
PISCIS
GRUS
PHŒNIX
ERIDANUS
HYDRUS
TUCANA
INDUS
Fomalhaut
Achernar
R(var)
T(var)
XXIV
XXIII
XXII
I
II

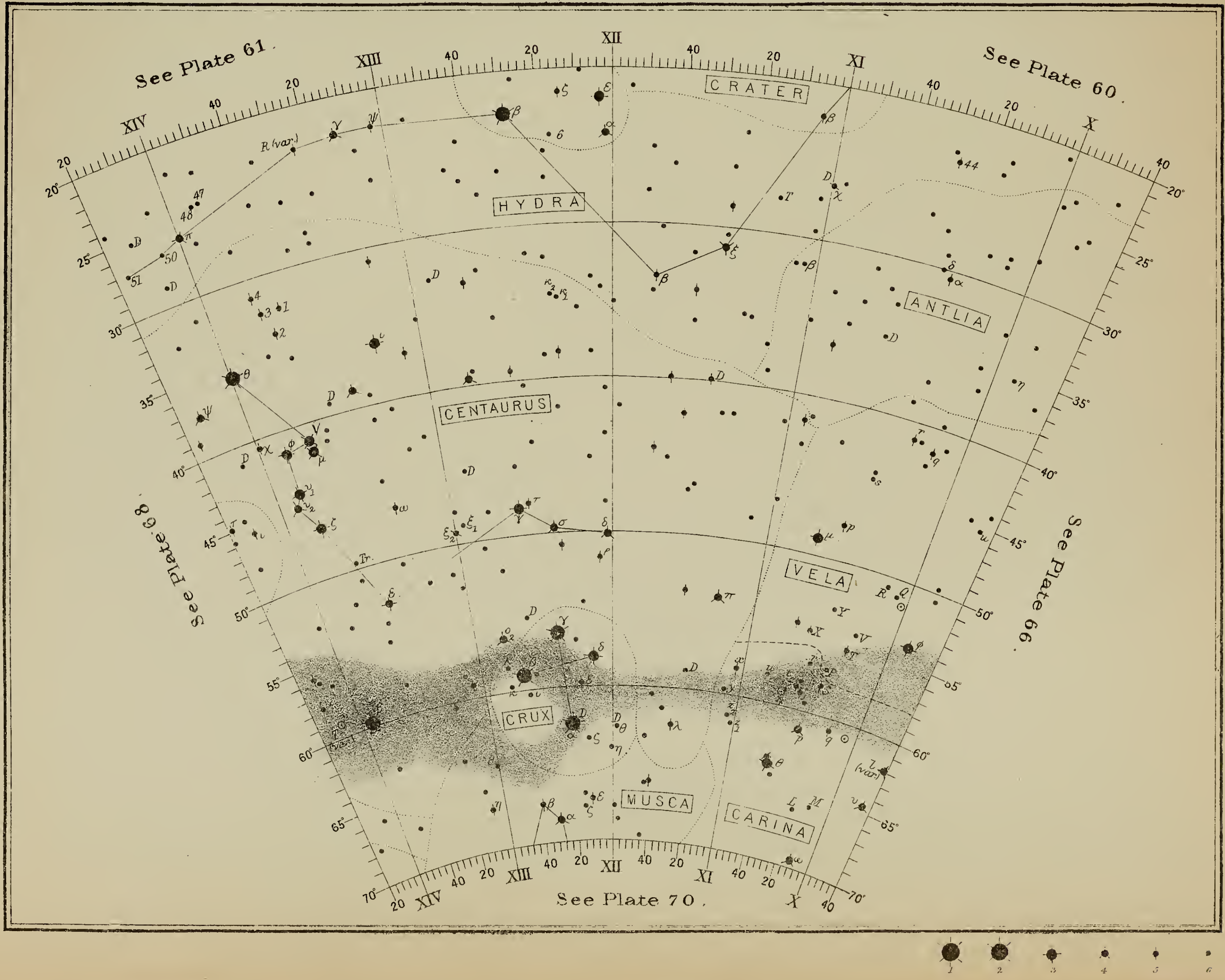
STAR MAP.


See Plate 59.
See Plate 58.
See Plate 60.
See Plate 64.
See Plate 70.
LEPUS
COLUMBA
CŒLUM
FORNAX
PHŒNIX
ERIDANUS
HOROLOGIUM
PICTOR
DORADO
RETICULUM
HYDRUS
α – Achernar
R(var)

STAR MAP

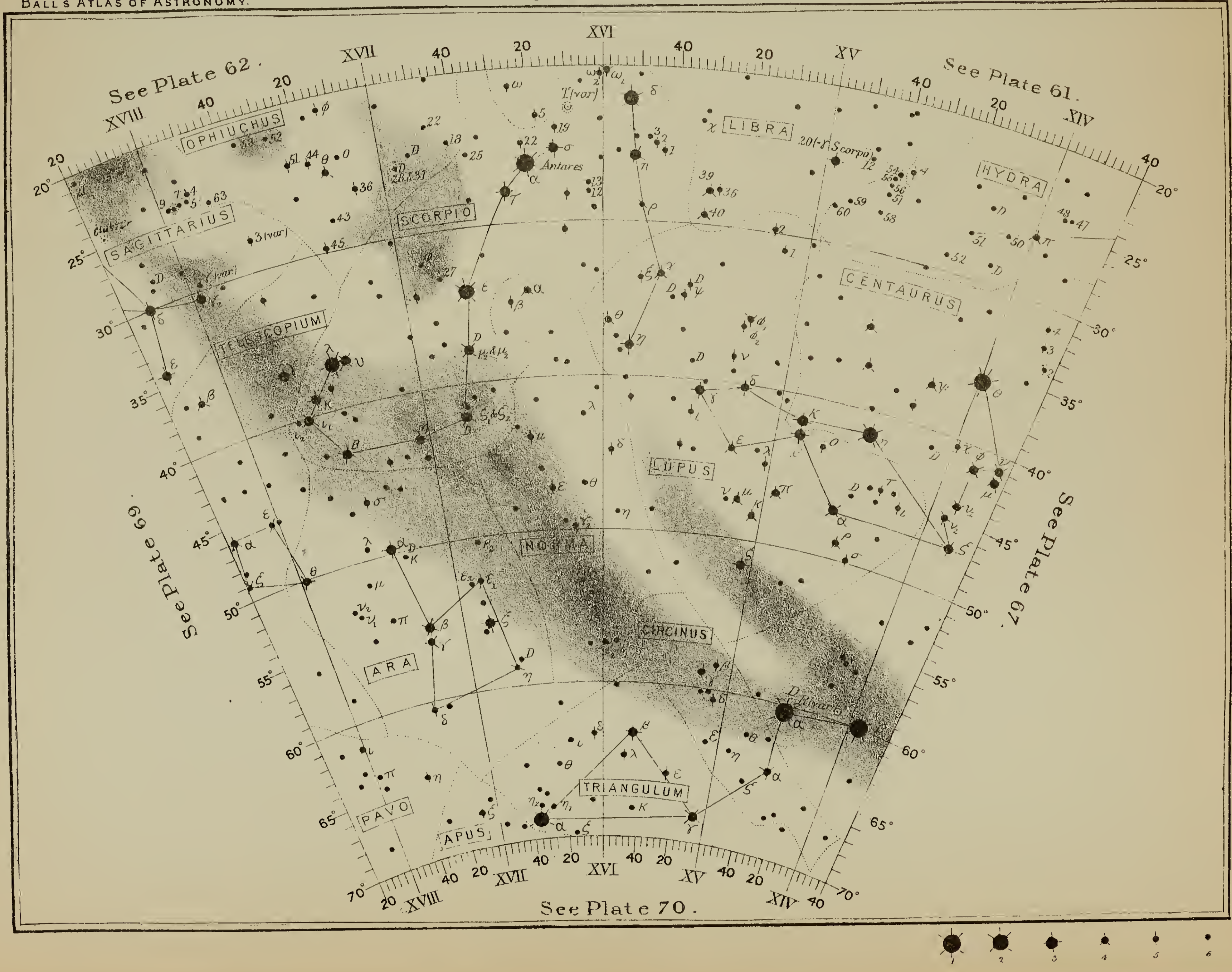

See Plate 60.
See Plate 59.
See Plate 65.
See Plate 67.
See Plate 70.
HYDRA
MALUS
PUPPIS
CANIS MAJOR
COLUMBA
ANTLIA
VELA
CARINA
PICTOR
VOLANS
α = Canopus
VIII
IX
X
VII
VI

STAR MAP.



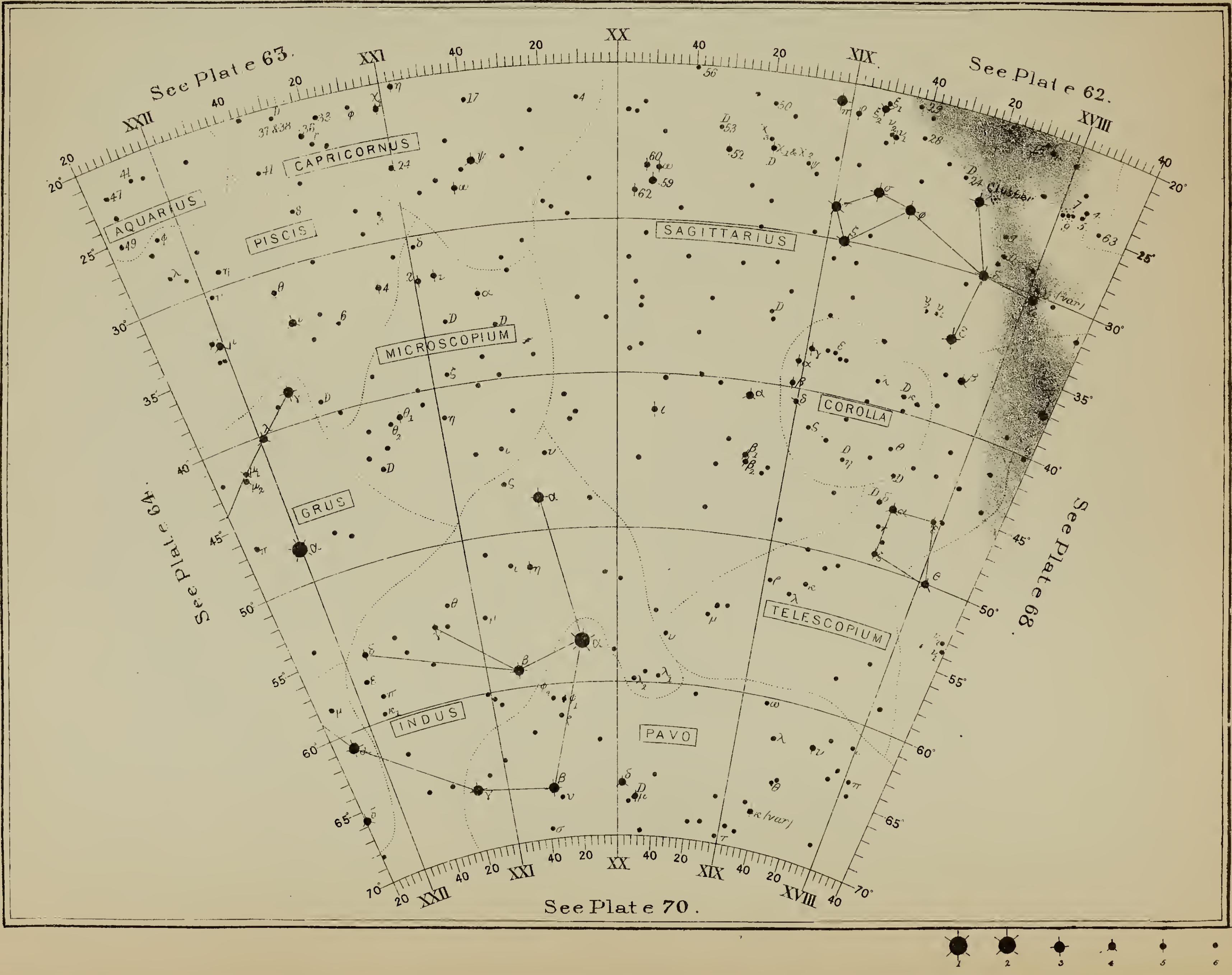
See Plate 61.
See Plate 60.
See Plate 66.
See Plate 68.
See Plate 70.
HYDRA
CRATER
ANTLIA
CENTAURUS
VELA
CRUX
MUSCA
CARINA
XIV
XIII
XII
XI
X

STAR MAP

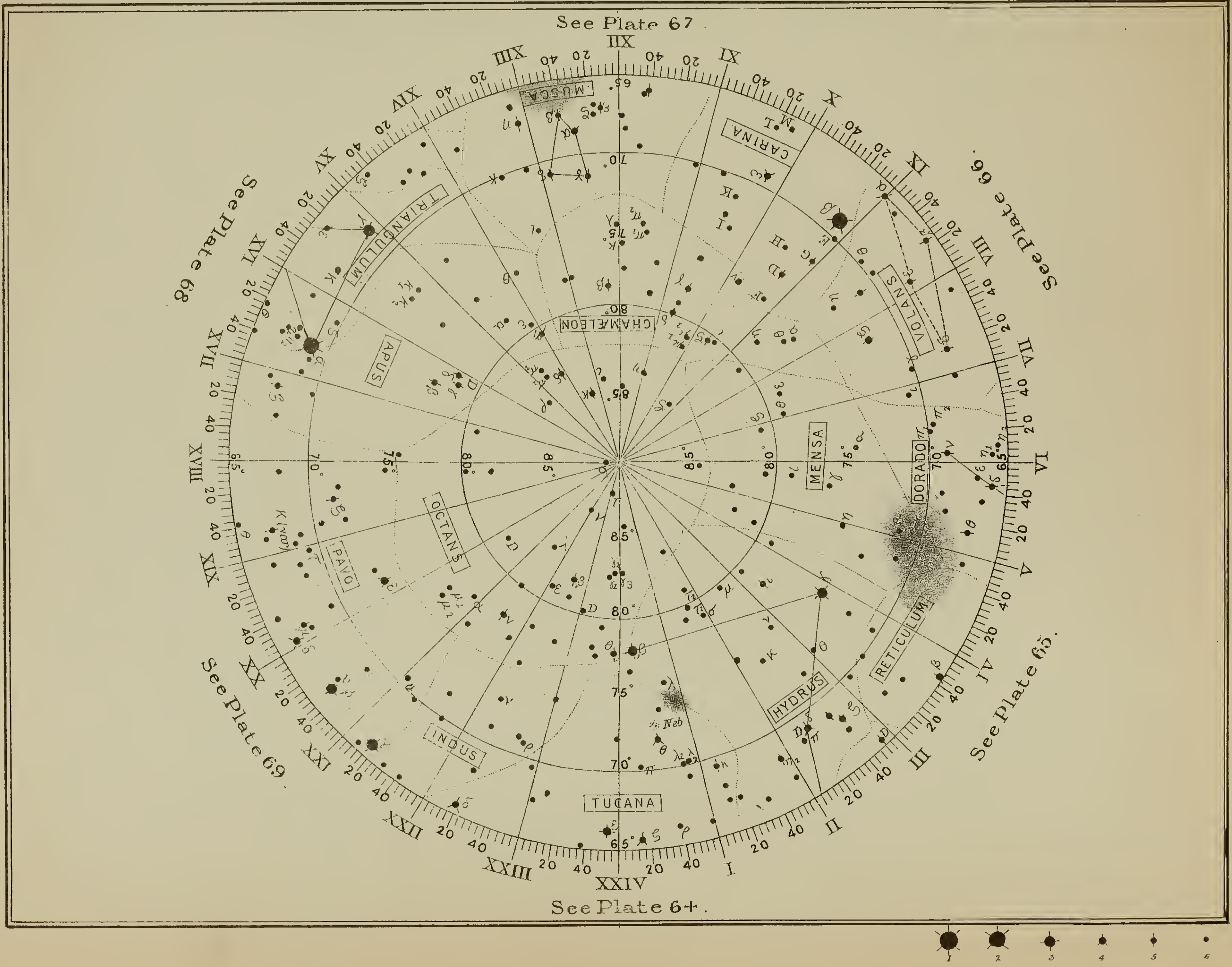


See Plate 62.
See Plate 61.
See Plate 67.
See Plate 70.
See Plate 69
OPHIUCHUS
SAGITTARIUS
SCORPIO
Antares
LIBRA
20 (-γ Scorpii)
HYDRA
CENTAURUS
TELESCOPIUM
LUPUS
NORMA
CIRCINUS
ARA
TRIANGULUM
PAVO
APUS
XIV
XV
XVI
XVII
XVIII

STAR MAP


See Plate 63.
See Plate 62.
See Plate 64.
See Plate 68.
See Plate 70.
AQUARIUS
CAPRICORNUS
PISCIS
MICROSCOPIUM
SAGITTARIUS
COROLLA
GRUS
TELESCOPIUM
INDUS
PAVO
Cluster
XXII
XXI
XX
XIX
XVIII
1
2
3
4
5
6

STAR MAP


See Plate 67
See Plate 66
See Plate 65
See Plate 64
See Plate 69
See Plate 68
MUSCA
CARINA
VOLANS
DORADO
RETICULUM
HYDRUS
TUCANA
INDUS
PAVO
OCTANS
APUS
TRIANGULUM
CHAMÆLEON
MENSA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Ursa Minor
Ursa Major
Cassiopeia
Cepheus
Draco
Andromeda
Pegasus
Perseus
Triangula
Pleiades
Hyades
Taurus
Auriga
Gemini
Canis Minor
Canis Major
Orion
Lepus
Eridanus
Aries
Cetus
Pisces
Leo
Hydra
Crater
Corvus
Virgo
Libra
Serpens
Bootes
Corona
Hercules
Ophiuchus
Lyra
Cygnus
Aquila
Delphin
Aquarius
Capricornus
EQUATOR
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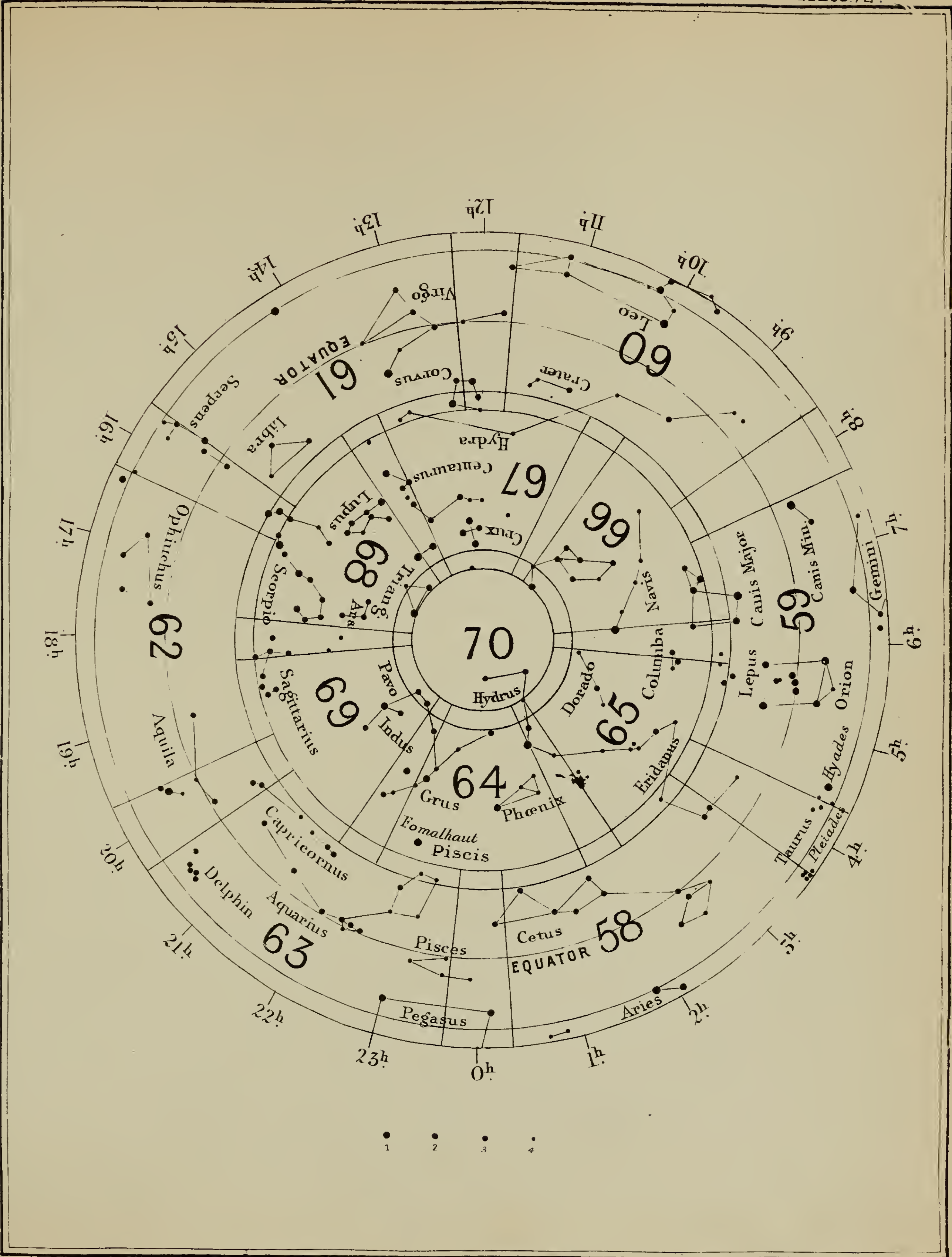

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Hydrus
EQUATOR
EQUATOR
Virgo
Leo
Corvus
Crater
Hydra
Centaurus
Crux
Lupus
Libra
Serpens
Ophiuchus
Scorpio
Triang.
Ara
Pavo
Sagittarius
Aquila
Indus
Grus
Phœnix
Fomalhaut
Piscis
Capricornus
Delphin
Aquarius
Pisces
Cetus
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Canis Min.
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